AUTOMATION

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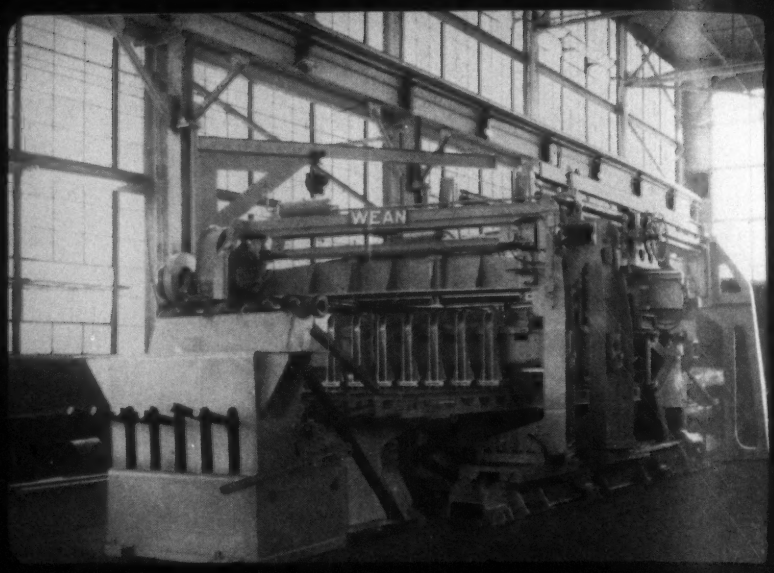
MANAGEMENT
OPERATION • DESIGN • ENGINEERING

PROCESSING • HANDLING • PLANT
MACHINES

need an idea?

Wean Trapezoidal Shear Line Solves Problem for Auto Maker



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MAY, 1955
Vol. 2—No. 5

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

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automation outlook

PARTIAL AUTOMATION TOO

". . . but automation can be both practical and feasible on a limited basis. It is not required or necessary that a total production process be involved. Some one part of a production process may lend itself readily to automation. This is particularly true where the process involves a great deal of materials handling . . ."—*Allan Harvey and Sol Tanne, Consulting Engineers, Dasol Corp., New York.* *See Page 68.*

CAN NEVER ACCOMPLISH

". . . while there is practically no limitation on the mechanical processes which can be accomplished by machinery, there is one human function that machines can never accomplish—and that is the exercise of intelligence and judgment! For example, regardless how automatic the production and assembly of component parts for any machine or mechanism may become, it is the design engineer who must conceive . . . in order to establish sound bases for the design of parts, machines and factories that will bear little resemblance to those we know now . . ."—*Drop Forging Topics.*

DATA-HANDLING ADVANCE

". . . I believe we shall advance in our mastery over the records we create, rendering them easier to consult by means which would now seem strange and bizarre to us, which will make obsolete much of what we now do, but which will give a new power and freedom to the creative mind and thereby open the way for another spurt forward of civilization. For civilization advances only as it acquires new experience and only as it makes its experience available and useful . . ."—*Vannevar Bush, president, Carnegie Institution of Washington.*

WILL ADD MORE PEOPLE

". . . in the immediate future, automation will be applied mainly to new plants and to new fields to meet the need for expanded production facilities. Rather than displacing labor, these automated plants will add more people to the work force . . . Automation seems likely to be a piecemeal, gradual transformation, and the effects will take place during so long a time-span and over so wide an area that the over-all effect on a dynamic growing economy will be comparatively small . . ."—*Industrial Relations News.*

WILLING TO WORK AND LEARN

". . . from the standpoint of the worker, automation will not eliminate jobs; it will supplant heavy, dangerous and unpleasant jobs with easier, more skilled, more pleasant and more interesting jobs. Automation will bring vast new opportunities to many workers who are willing to work and learn. We are faced with the task of finding the best and brightest people in the work force and training them to the more skilled requirements of these new jobs. And anyone who receives such training, at Ford or elsewhere, is in a very fortunate position. He is in on the ground floor of what promises to be a tremendous factor in our industrial future. We believe that automation is part of a tremendous force operating in the American economy to the benefit of all elements of our society . . ."—*R. H. Sullivan, vice president and group executive, Ford Motor Co.*

LESS NEED FOR INCENTIVE

". . . since the basic job to be done in an automatic factory is to keep the machines running, to maintain them so systematically that they function without trouble, and to repair them promptly when they break down, there may be less need for incentive systems. Workers will need far less supervision, for it will be their job to supervise the machines. The proportion of skilled workers in the labor force will rise sharply. This proportion will differ somewhat from industry to industry, so no exact estimate can be made, but there appears to be no question that automation will bring a general upgrading of workers. This has already occurred in the oil and chemical industries . . ."—*Carl F. Oechsle, Deputy Assistant Secretary of Commerce For Domestic Affairs.*

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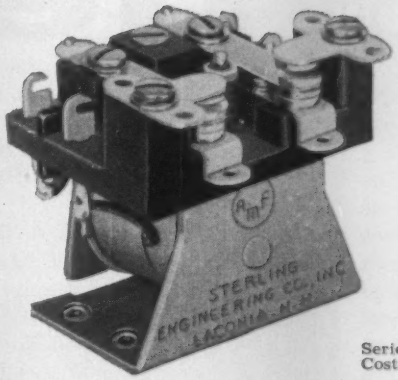

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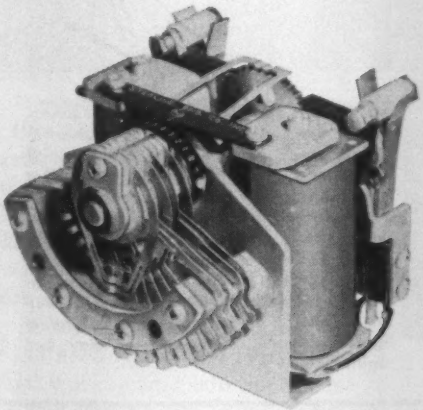

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AUTOMATION news

Today's events and developments in the field of automation

Automatic Toll Collector —You Can't Beat It

AUTHORITIES anticipate that the use of a mechanized toll collector, developed by Taller & Cooper Inc., will facilitate traffic flow as well as effect substantial economies by freeing extra personnel from toll booth duty. Trial unit has been placed in operation on New Jersey's new Garden State Parkway. Unit consists of a coin receiver, fraud-detection camera installation and a special axle-counting treadle. Coin box is provided with a bowl-like opening within easy access to the driver. Unit receives nickels, dimes and quarters in any combinations. If the correct amount is noted by the sensing switches, a green light signals the driver to proceed and the money passes into a depository. A printed record of the transactions occurs at a remote recording device.

Should the driver fail to stop or if an incorrect amount is deposited, an alarm is set off which summons an attendant. Simultaneously a relay circuit is energized which cocks the shutter of the automatic camera. If the car proceeds, the axle counting treadle will trip the camera's shutter, taking a picture of the lower rear portion of the automobile. Lens and shutter of the camera are self-adjusting to varying light conditions. Same signal which activates the camera also switches on a flood light when it is dark. Frame of film for each evading autoist also records time of day, date and place of occurrence for complete evidence.

Special treadle counter is reported to be tamper proof. It will respond only to moving vehicles and is capable of recording direction of movement to take care of vehicles which might back up over the treadle. Main purpose of treadle is to provide accurate count of number of vehicles passing through a given gate. Count is registered automatically at a distant control point and compared with money receipts. Treadle is designed to count accurately under all temperatures and weather conditions.

AUTOMATIC toll collector accepts nickels, dimes and quarters from motorists at New Jersey's Garden State Parkway. If the motorist attempts to outwit the gadget with insufficient funds or to pass without paying anything an alarm goes off, red signals flash and a camera is automatically cocked so that the wheels of his own moving car trip a shutter and snap a picture of his license plate. Lens and shutter of camera are self-adjusting to varying light conditions throughout the day and night.

Upgrading Must Keep Pace With Automation

IF AUTOMATION confronts us with a second industrial revolution, it will be an intellectual revolution, **Dr. Gordon S. Brown,** head of the department of electrical engineering at Massachusetts Institute of Technology, told the MIT Midwest Conference at the Mid-Day Club, Cleveland. "The whole issue is: are we bright enough to upgrade our competence to keep the machines running," Dr. Brown

said. "Society has made more and more exacting demands upon the machine. We have demanded uni-

formity and high standards in quality and we have demanded enormous production in quantity. This has resulted in greater demands on manipulative skills of the workers. But a worker can turn only so many knobs. Gradually his manual dexterity has been overtaxed. This problem has been solved by computers which control machine systems automatically. The massive computer has caused an industrial explosion. Calculations are performed which the human being is incapable of performing. Now the question arises whether we will have enough workers qualified to control the machines. A steel worker trained merely to read and repair thermometers, pressure gages and flowmeters is not prepared to operate and repair electronic devices.

"I contend that unless we plan intelligently today labor will not be competent to move into the multitudes of jobs upgraded as a result of automation. We already face the need for a new type of industrial worker who will have more brain and less brawn. This situation will give rise to problems throughout all levels of society. Labor must face up to these problems and so must management, for management must also become prepared to move into an upgraded job as business machines step up the tempo of data-gathering for the boss. Business judgment is becoming more quantitative — the seat-of-the-pants hunch less adequate.

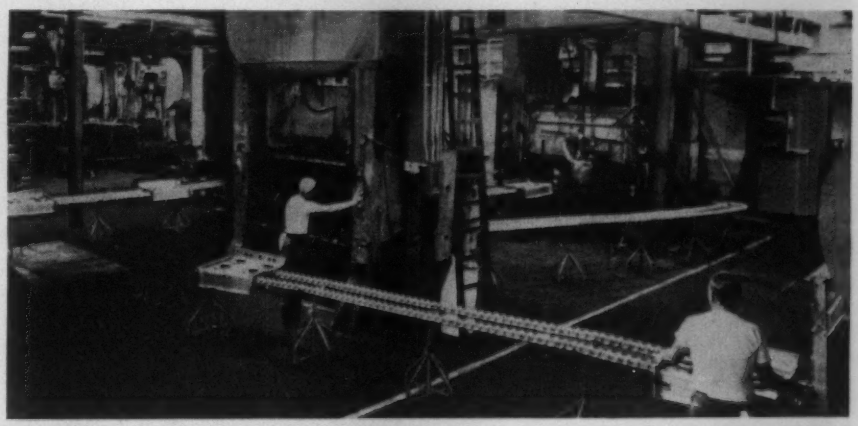
"Labor wants an increased standard of living and shorter hours. Automation can provide these things, but labor and management must learn the new skills and must learn that mobility and planning are the keys to survival. There will not be any shortage of jobs—only the people qualified to fill the jobs. The pace by which automation arrives will be measured by the speed with which men are trained to control the new machines."

Automatic Direction Finder

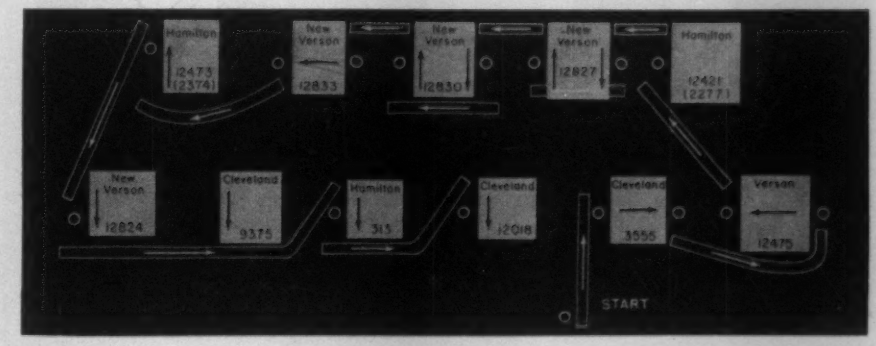
USEFUL AID to mariners has been introduced by Raytheon Mfg. Co. New automatic radio direction finder, specifically designed to operate in 275 to 510 kilocycle and 2 to 3.5 megacycle bands, has seen service on Coast Guard vessels. Unit indicates bearing of any radio station to which set is tuned. Exact position of receiver vessel can be found by simple triangulation methods. Bearing of ships in distress can be determined quickly and accurately. Unit was developed in co-operation with U. S. Coast Guard for search and rescue missions and promises to be a valuable accessory for commercial fleet operators and owners of pleasure craft.

Printing on Paper By Electrostatic Charges

DEVELOPMENT of a new superspeed process called "Electrographic Recording" which will print calculations of an electronic computer at the rate of 5000 characters a second, has been revealed by Burroughs Corp. The new printing technique was described by **Dr. Herman Epstein** at the West Coast Computer Conference as essentially a three-stage operation. Characters first take the form of a pinpoint pattern of electrostatic charges on the surface of a low cost coated paper. Next, the pattern is made visible by passing the paper through a dry ink bath. Here, tiny particles of powdered ink cling to the pinpoint areas where the paper has been charged. The



PORTABLE folding stands supporting lengths of Alvey-Ferguson conveyors are set up as needed for a variety of recurring materials handling operations at RCA-Estate Appliance Co. Company plans to maintain a "squad" of conveyor equipped stock trucks to provide automation where and when needed. Plan view of conveyor sections placed for automatic handling in press area is shown below. Sections are sloped slightly between machines so that work flows smoothly from operation to operation.



paper then rolls through a third station where a temperature controlled hot plate "fixes" the ink permanently, making it fade proof and smudge proof. The paper moves continuously through the three stations at a steady rate of speed up to 44 feet per second. The end result is a line of uniform, clearly visible printed characters with virtually no background discoloration.

The initial electrostatic image of each character is created by passing a short burst of electric current through selected wires in a 7 x 5 matrix. Each image is formed on the paper in three millionths of a second. The selection of the proper wires to form successive character patterns is carried out electronically by an encoder which reads punched paper tape, magnetic tape or punched cards, or translates directly from an electronic computer. The only moving parts are those necessary to keep the paper in continuous high speed motion, and operation is silent except for the sound of moving paper. The current laboratory model is being used as a basis for further research into the development of this new art and for exploring its full potential for business, industrial, and governmental use.

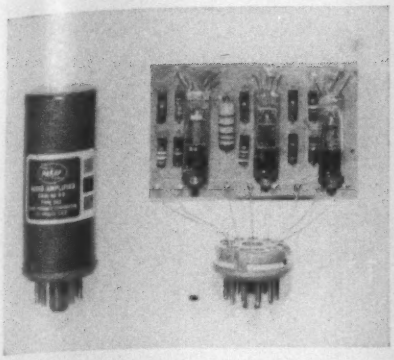
Population and Automation

COUNCIL for Technological Advancement, an affiliate of Machinery & Allied Products Institute, has issued a study of the trends in population and the labor force. The council concludes that living standards will continue to rise as productivity increases with the introduction of automatic processes and other technical improvements. Jobs will increase as markets with higher living standards increase and in particular, job opportunities for women will increase because less physical strength will be required for tomorrow's jobs. It is anticipated that young people will require more education as jobs become more technical and that they will be able to get this education as living standards rise. The study foresees that the historic trend toward concentration of population in large urban centers will slow up or come to a halt as new plants, constructed to take advantage of automation, are built away from congested centers. The proportion of the population engaged in trade, service and manufacturing is expected to rise and the proportion in agriculture and mining is expected to decline.

OPERATORLESS tractor train is shown making its way through a plant. Train is following a route set by guide wires strung from the ceiling overhead. Unit, developed by Barrett-Cravens Co., is controlled by radio waves transmitted over the wires from signal boxes installed at desired locations throughout the plant. Truck can be called to any station by simply pressing a button at that station. Truck contains an electronic device that operates automatically to set truck in motion to follow a given wire path at some predetermined speed. If desired, guide wire may be placed in small slot in the floor.

DESIGNERS and manufacturers of automation machinery, Automation Engineering Laboratory has announced the appointment of **Robert C. White** as sales manager.

White was formerly associated with the Syntron Co., manufacturers of electrical vibrators, tools, and feeder mechanisms. His experience with automatic feeder equipment and continuous drying equipment in the chemical, pharmaceutical and food processing fields has led Mr. White to comment, "It is through the advantages of automation in industry that American labor, with its high standard of living, can compete successfully with the cheap foreign labor markets."



PACKAGED CIRCUITS, etched on impregnated Teflon, are rolled and cased for final utilization. Unit developed by Audio Products Corp. is offered in three series having wide application in computer and airborne instrumentation, laboratory equipment and high fidelity audio amplification. Seated height is 2¾-inches.

NEW PRESIDENT of the Ampex Corp., **George I. Long,** has indicated that encouraging results have been obtained in Ampex's project

to determine the feasibility of using magnetic tape as a medium for the reproduction of television programs. Long replaces **Alexander M. Poniatoff** who has been elected Chairman of the Board of Directors of Ampex. Company engineers are progressing in the development of other new products, such as automatic programming systems for radio stations (see AUTOMATION, April 1955) stereophonic sound reproducers for the high fidelity market and airborne instrumentation recorders for flight testing of aircraft and missiles.

Atomic Exposition

PLANS have been completed for the Atomic Exposition and Nuclear Congress to be held in Cleveland in December. Nonclassified exhibits

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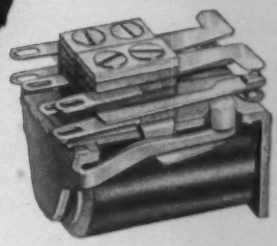

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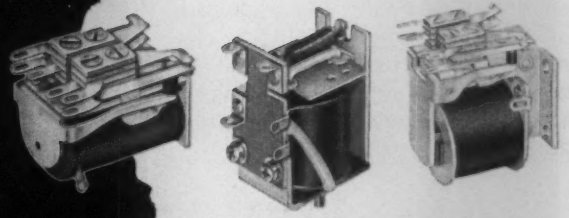

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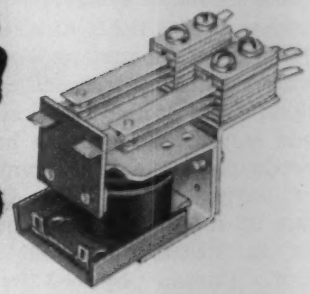

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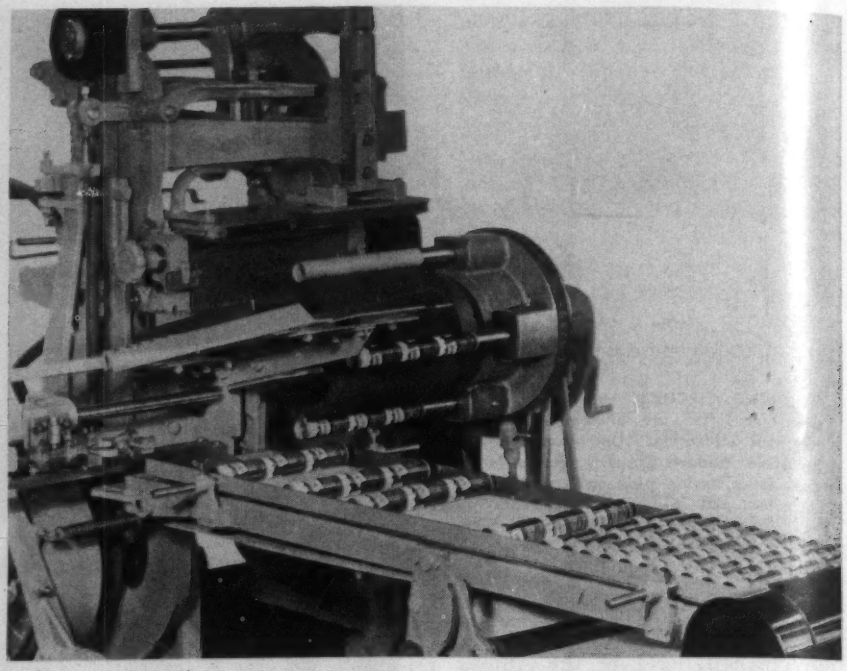
of the Exposition will go beyond those of direct interest to the nuclear scientists and engineers participating in the Congress. Under sponsorship of the American Institute of Chemical Engineers, the Exposition, directed by **Athel F. Denham,** is being tailored to interests of six basic audiences: (1) Users and potential users of materials, equipment and services based on nuclear developments; (2) companies outside the nuclear industry seeking developments that can be applied to their fields; (3) management, engineering and scientific personnel in the nuclear power and allied fields; (4) producers of components, materials, equipment and services for use in the nuclear industry; (5) representatives of government and education and (6) the general public.



MODIFIED LABELING MACHINE developed by New Jersey Machine Corp. can label 40 paper tubes per minute automatically. Wound paper tubes are fed by inclined chute onto rotating mandrels. Label is fed from hopper, passed over glue roll and attached to tube; tube and label are then rolled against a pressure pad as mandrel turret indexes to succeeding stations. Conveyor discharges completed work at point convenient to loader-operator. Prior to this, most tube labeling has been accomplished either by hand or by semiautomatic methods.

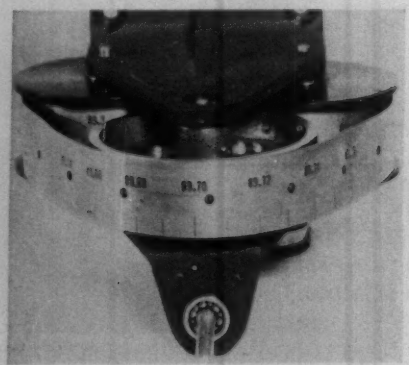
Results of Research At National Bureau of Standards

ORIGINAL research by the National Bureau of Standards covers many fields. Among some of the developments seen at a recent open house attended by several hundred leaders in the fields of science, industry, government and education were results of Bureau's investigations of an atomic flame and a diode amplifier. A flame has been produced by the direct combination of oxygen atoms with acetylene gas at a low pressure equivalent to an altitude of about 200,000 feet. Bureau physicist **Dr. H. P. Broida** explained that the actual temperature of the bluish green flame is not known. Measured temperature varies from 1200 to 20,000F depending on the thermometer used. Purpose of the flame study is to obtain information for jet engine and rocket operation at high altitudes and to learn more about burning under ordinary conditions for more efficient use of industrial fuels.

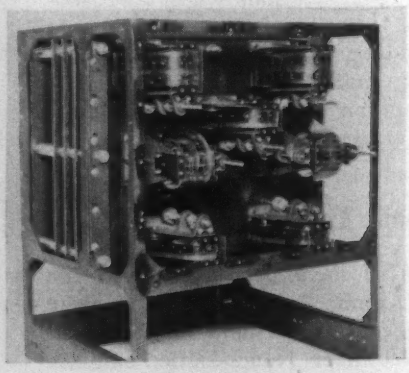
The diode amplifier, known as the diamp, has been developed as a substitute for the transistor, (See AUTOMATION, Jan. 1955). In attempting to improve characteristics of germanium and silicon crystal diodes, Bureau scientists have perfected a diode which operates in a fashion similar to a transistor with the added advantages of higher operating rates, lower cost and wider availability.

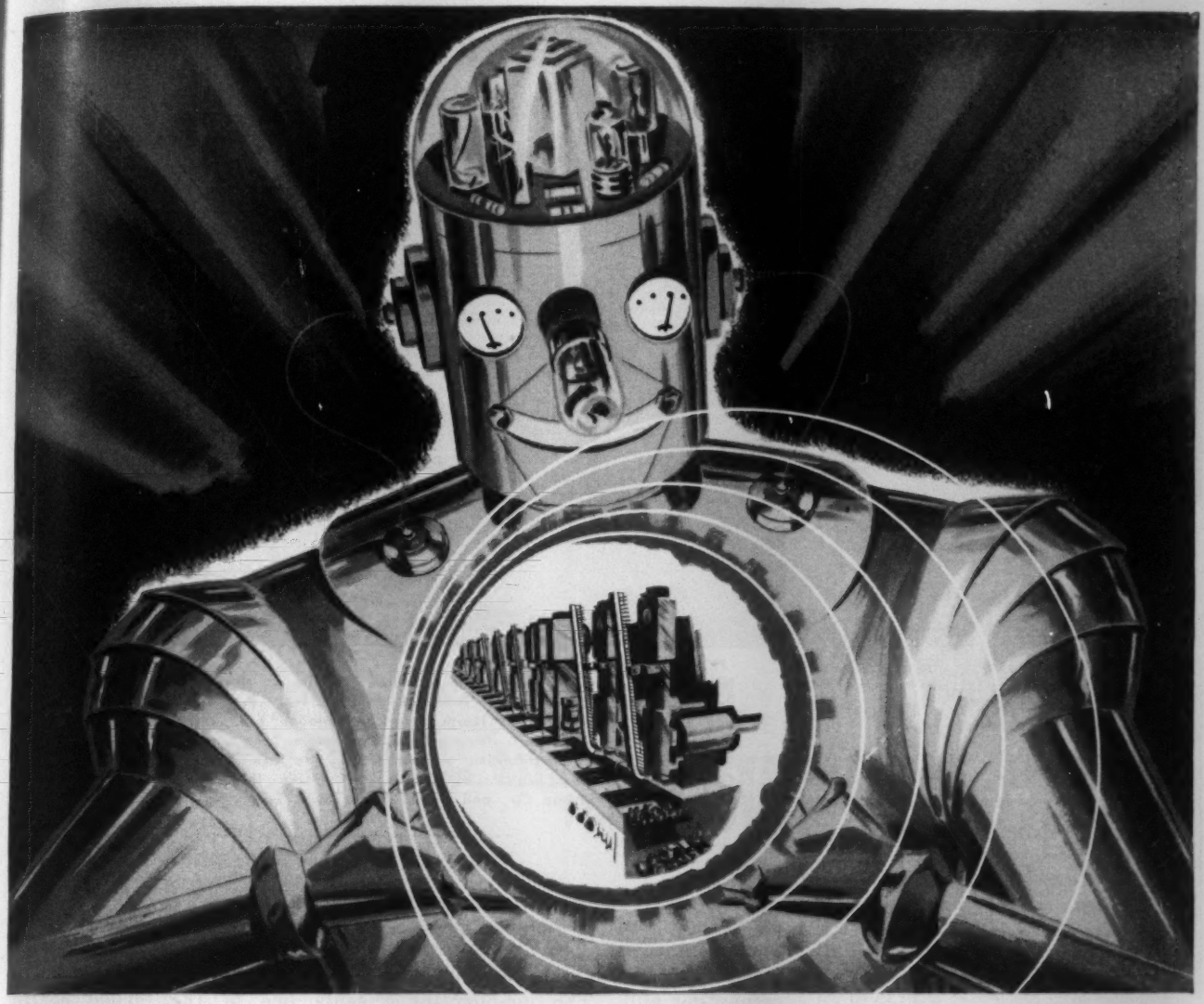
Designed for Small Concerns

SPECIAL data processing machine has been designed by International Business Machines Corp. for small business operations. The machine includes an electric typewriter, auxiliary numerical keyboard, equipment for reading punched



EXPANDED SCALES in which the graduations are printed on long strips stored on drums solve one of the problems which miniaturization creates for precision instruments. Effective accuracy of precision instruments is often limited by the degree of readability and exactness of the scale. New scale, developed by Ultrasonic Corp., is accurate to within ±0.0033 inch over 100 inches of scale length. Flat strip of stainless steel, prestressed to form a tight coil when free, is wound on take-up drums and driven by sprocket on drive drum which is operated through a typical gear train.





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PHYSICISTS

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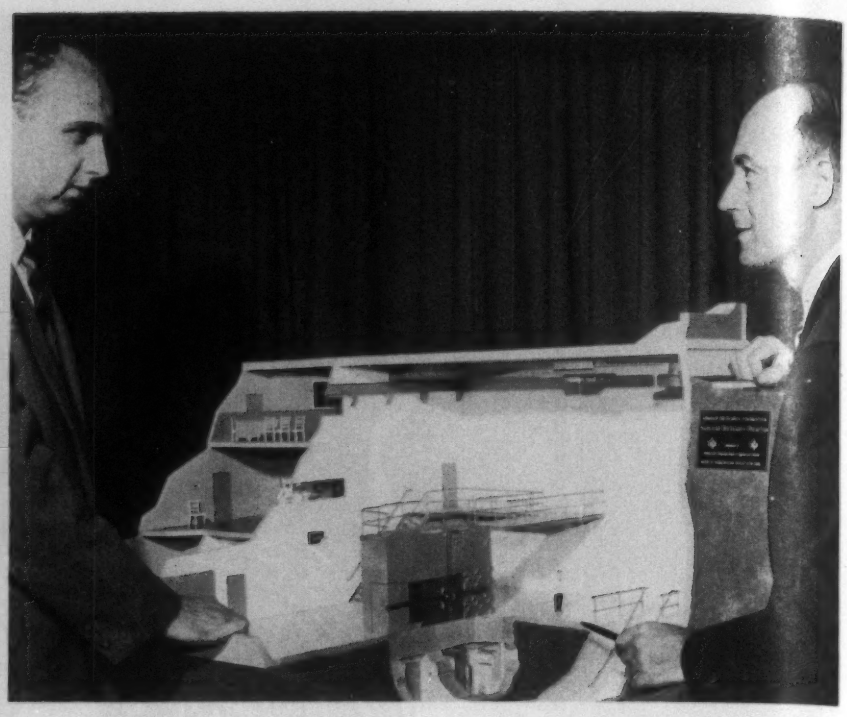
RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California



NUCLEAR REACTOR for industrial research will be constructed at the Armour Research Foundation by North American Aviation Inc. Dr. Robert Loftness, left, and Dr. Harry Pearlman of North American Aviation are shown with a model of the proposed installation. Nine industrial companies have signed as participators in the reactor research program: Armour & Co., Aro Equipment Co., Borg-Warner Corp., Elgin National Watch Co., Illinois Tool Works, Inland Steel Co., M. W. Kellogg Co., Richardson Co., and United States Steel Corp.

cards and controlling the entire operation according to a preset program, and an auxiliary automatic computing unit. The one-operator system is developed around prepunched cards for commodities, constant customer data, standard pricing information, etc., and the fact that much of the handling of paperwork involves a standard procedure which can be precoded into the constant data cards. In addition to making up billing forms, shipping tags, invoice registers, and internal work orders, the system can be made to yield punched tape and cards for mailing to general offices for statistical and accounting purposes.

Trouble Shooting Automated

ELECTRONIC DEVICE that uses 710 miles of wiring to keep a finger on approximately 25,000 control points is used to check performance of three new automatic bumper plating lines at Chevrolet's new spring and bumper plant. Upright illuminated panels carry a complete diagram of the electrical layout controlling each plating machine. Each point on the diagram represents one of the 25,000 control points and is wired directly to that part of the machine. Simply by using a test probe, much like a telephone operator, an electrician can "tune in" instantly on any one of the thousands of points and tell how that part of the machine is performing. Checking can be done with power on. This system eliminates traveling the length of each 535 foot long machine to locate trouble.

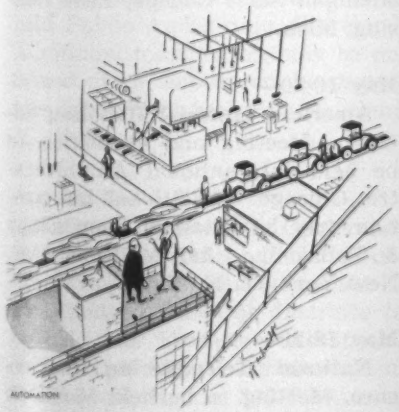
NEW VICE PRESIDENT in charge of engineering and research has been announced by **R. B. Werey**, president of Conoflow Corp., manufacturer of pneumatic final control elements. **Warren H. Brand** who assumes new duties with Conoflow, is well known in the fields of instrumentation and automatic controls. He is national president of the Instrument Society of America, and before joining Conoflow,

served with the Atomic Energy Commission as supervisory engineer of the industrial instruments section at Oak Ridge National

Laboratories. A graduate of Cooper Union College of Engineering, Brand carries registered professional engineer's papers and is active in a number of engineering societies.

Microwave Relay System For TV and Telephone

TWO NEW microwave relay systems, one for relaying telephone messages and dialing signals, the other for carrying TV programs in full color or black-and-white, with sound, have been demonstrated to federal government agencies and representatives of industry by the Raytheon Mfg. Co. One system can bring telephone service into remote rural communities where service does not exist because of the difficulty or cost of stringing miles of wire on poles. The narrow microwave beam, carrying up to seven two-way messages simultaneously, spans wild and rugged timberland, mountains, lakes, and is impervious to storms, falling trees,



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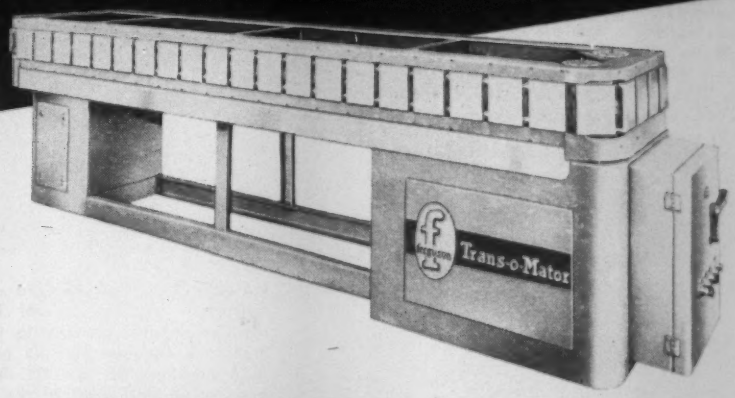

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THE TRANS-O-MATOR IS A STANDARD MACHINE

containing a complete power transmission unit, including motor, reducer, clutch, Ferguson Roller Gear Drive for high speed precision indexing, chain and carriers. There is an electrical interlock system between the indexing and the tooling power supply as well as start, stop and jog controls and provision for an automatic scanning device to insure proper function of all stations.

MECHANIZE YOUR MANUAL OPERATIONS

Add tooling as required to perform assembly, forming, pressing, light machining and inspection operations.

★ 20,000 pieces per hour ★ Tool and retool as required

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ROLLER GEAR DIVISION, DEPT. AT-5. P. O. BOX 191, ST. LOUIS 21, MO.

(Advertisement)

VHS* RELAY

(*Very High Sensitivity)

Model 266

Sample specs. are: 0.2 micro-amperes, (12,000 ohms coil) or, 0.1 millivolts, (5 ohms.)

• The VHS is a balanced armature, Alnico magnet type relay. It is internally shock-mounted and resistant to vibration. The screw-on cover is gasket sealed. It can be opened and resealed.

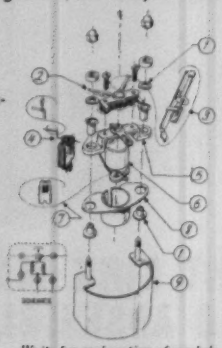
Connections: 9 pin octal style. Dimensions: 1¾ diameter x 2¼ long. Weight: 4 ounces. Sensitivity: Infinite variations from 0.2 Ua. to 10 Amp. or 0.1 Mv. to 500 volts, self contained. Higher volts or amps with external multipliers. A.C. rectifier types. Trip point accuracies to 1%. Differential 1%. The degree of resistance to shock and vibration primarily depends upon sensitivity and type of action wanted. In general, the relays will not be permanently damaged by shocks of 100 G's and vibrations up to 2,000 cps at 4 G's. The most sensitive relays may close their contacts under these conditions.

Contacts: SPST or SPDT, 5-25 Ma. D.C. Other ratings to ½ Amp. A.C. A locking coil gives high pressure and chatter free contact under shock and vibration.

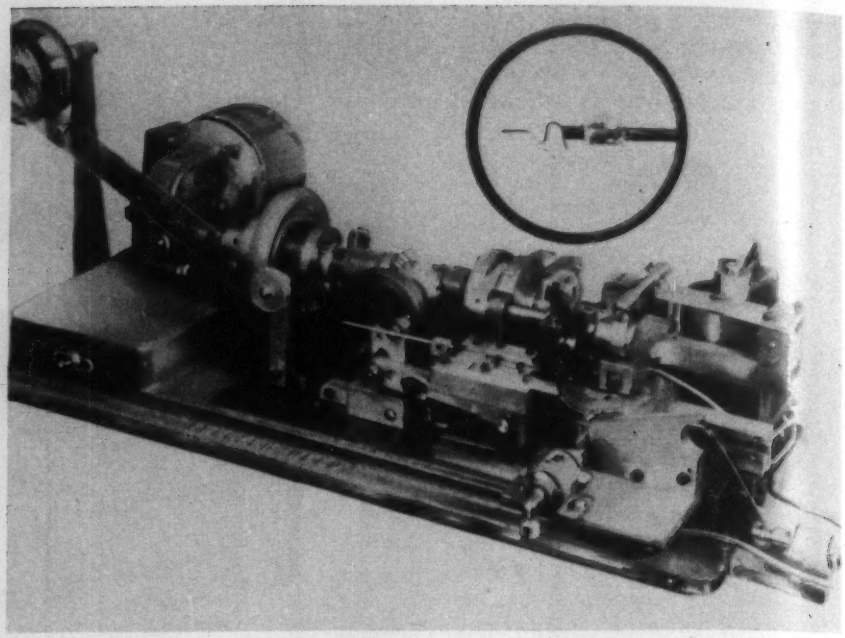
Prices: $20 - $80.

Delivery 4 to 6 weeks.

Assembly Products, Inc., Chesterland 27, Ohio.



Write for explanation of symbols



MANUFACTURER of standard and special purpose equipment for small and miniature parts welding, Federal Tool Engineering Co., has developed an automatic machine capable of welding 0.001 inch diameter wire to precision specifications. Welder is designed to weld gold whisker wires on diodes. Wire may be formed to a specified "U" or "S" shape and cutoff at either 30 degree or 45 degree burr-free angle. Each of the wires is held to within ±0.005 inch radius of the pin centerline.

ice, and other hazards to wires. It provides an automatic, economical two-way communication system for use in the telephone, pipeline, construction, railroad, turnpike, and power utility industries. It also has advantages for logging and forestry applications, and is suitable for use by fish and game commissions. It can be connected to existing telephone, telegraph, teletype, telemetering, and other types of supervisory communications equipment without being changed or modified.

The television link picks up sound and color picture from the camera and microphone, and sends both signals back to the studio on one microwave channel. In a sense, the TV camera for the first time is free to roam the city's streets in quest of news, or attend ball games, etc., without the necessity of being connected to the studio by wires. With the reflecting antenna set up on a nearby rooftop, the beam can be focused on the studio up to 25 miles away where the program goes out on the air over conventional telecasting equipment. Units are light enough for one man to carry, including its luggage-type case, the aluminum "dish" or antenna, and tripod. Exceeding most FCC specifications, this equipment has proved its ability to relay color and black-and-white programs without loss of original quality in either sound or picture.

MEETINGS AND EVENTS

May 12-13—

Michigan State College. Symposium on automation sponsored by and to be held at School of Engineering, East Lansing, Mich. Additional information may be obtained from Prof. J. M. Apple, Michigan State College, East Lansing, Mich.

May 16-20—

American Material Handling Society. Meeting and exposition to be held International Amphitheatre, Chicago. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 18-20—

National Telemetering Conference. Meeting to be held Morrison Hotel, Chicago. Additional informa-

what article

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See page 104

tion may be obtained from Kipling Adams, 920 S. Michigan Ave., Chicago, Ill.

May 26-27—

Electronic Components Conference. Meeting to be held Ambassador Hotel, Los Angeles. Additional information may be obtained from Dr. Simon Ramo, 8820 Bellanca Ave., Los Angeles 45, Calif.

June 2-3—

Institute of Radio Engineers. Materials Symposium to be held Convention Hall, Philadelphia. Additional information may be obtained from M. A. Rudner, 611 North Tenth St., Camden 1, N. J.

June 7-10—

American Welding Society. National spring meeting and exposition to be held Hotel Muehlebach and Municipal Auditorium, Kansas City, Mo. Additional information may be obtained from Society headquarters, 33 W. 39th St., New York, N. Y.

June 14-16—

American Institute of Electrical Engineers. Conference and exhibit on magnetics to be held William Penn Hotel, Pittsburgh. Additional information may be obtained from Richard Rimbach, 845 Ridge Ave., Pittsburgh 12, Pa.

June 16-17—

Machinery and Allied Products Institute. Annual meeting to be held Statler Hotel, Washington. Additional information may be obtained from Institute headquarters, 120 S. LaSalle St., Chicago 3, Ill.

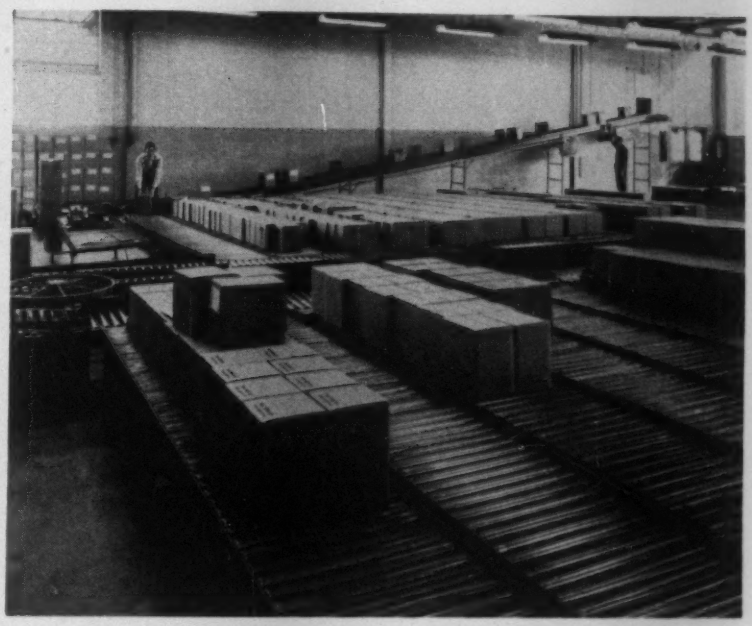
June 20-23—

American Electroplaters' Society. Annual meeting and exhibit to be held Public Auditorium, Cleveland. Additional information may be obtained from exposition headquarters, 1849 West 24th St., Cleveland 13, Ohio.

Aug. 22-23—

National Industrial Conference Board. Electronics and automation symposium jointly sponsored by Standard Research Institute to be held San Francisco. Additional information may be obtained from NICB headquarters, 247 Park Ave., New York, N. Y.

50 years of progress in CONTINUOUS-FLOW CONVEYING



● It was just 50 years ago, in 1905, that the first Mathews Conveyers were designed and built—and applied in a Minnesota warehouse. From that early equipment has evolved some very spectacular continuous-flow conveying systems—indeed, some of the real "show jobs" of the conveying industry.

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Engineering Offices or Sales Agencies in Principal American and Canadian Cities
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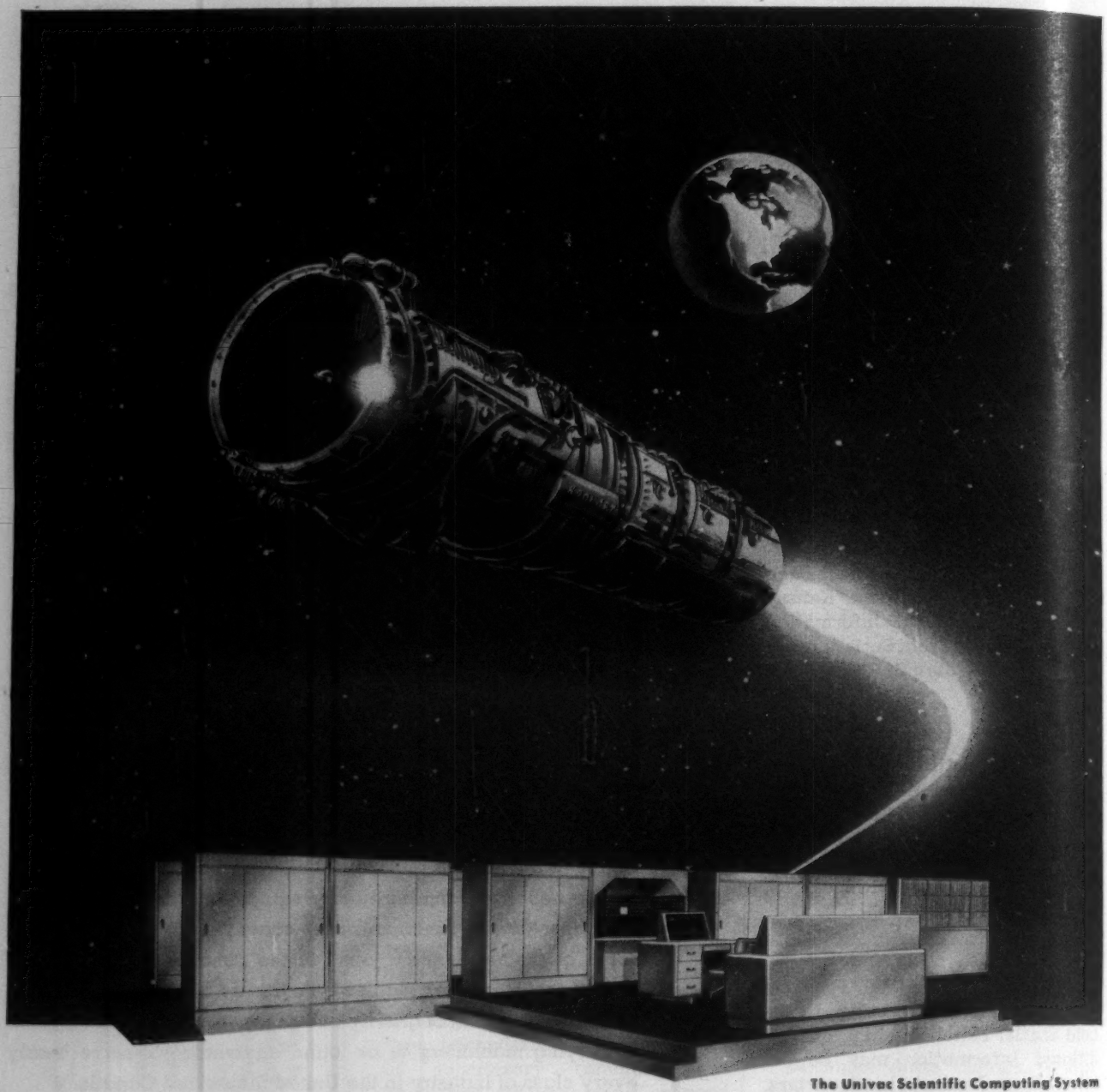
MATHEWS



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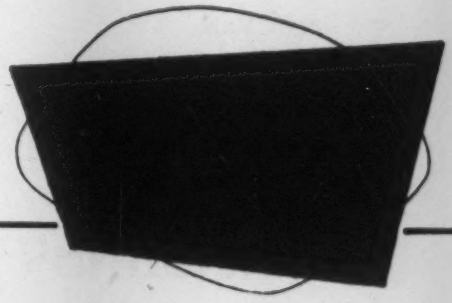


By FLOYD G. LAWRENCE, Detroit Editor

UNION BELABORS AUTOMATION

WHEREVER there's a cornucopia, leave it to labor unions to put the workers at the little end of the horn.

That's hardly surprising when you stop to consider that a labor union's primary business often seems to be in justifying its existence to the dues-paying members. But not a few management people are surprised to find automation included in guaranteed annual wage talk.

Mr. Reuther, a man with extremely flexible vision, observes that automation will increase productivity. But he goes on to note that more output per worker without increased total production is a "formula for depression." He, therefore, insists that purchasing power be increased sufficiently to match our productive capacity, not only through higher hourly rates, but also through steady work. And steady work is one of Mr. Reuther's ways of saying "guaranteed annual wage."

Thus a union publication says, "in the face of new and revolutionary technological changes developing in our economy, the establishment of the guaranteed annual wage becomes imperative for workers. The wealth-producing potential of automation is matched only by its potential for disruption and chaos unless harnessed in the interest of the nation as a whole."

The UAW-CIO also believes that under the guaranteed annual wage, the introduction of automation equipment would be geared to periods of expanding markets so that other jobs would be available for the workers displaced by automation.

"In the absence of the guaranteed wage, irresponsible corporate decentralization policies accentuated by the introduction of automation would leave thousands of workers stranded. With the guaranteed annual wage, a very substantial part of the costs of corporate irresponsibility in either the timing or the geographical placement of automation would be borne by management."

In short, the union is saying that increased productivity made possible by automation requires an increase in purchasing power and that automation is displacing workers who, therefore, require a year to find another job.

Automation is a word that lends itself to imagery and propagandizing. It makes easy phrases like "men walk idle and hungry—made obsolete as producers because the mechanical monsters around them cannot replace them as consumers".

Secretary of Commerce, Sinclair Weeks, observed recently that "scaremongers are trying to frighten automobile workers with the bogeyman of automation." For his trouble he was charged with "reckless irresponsibility" and "dividing the American people into warring economic groups." The point of issue, of course, lies in the fact that the UAW-CIO considers automation a bogeyman only if management does not accede to wishes of the UAW-CIO. And if management does, the UAW can claim credit for the first trip to the moon.

Perhaps it is appropriate that the man who originated the term deliver the blow for the defense of automation. And, as Del S. Harder, executive vice president—Basic Manufacturing Divisions, Ford Motor Co., says, "the era of automation is nothing more than a continuation of the industrial revolution which greatly increased our national wealth, created millions of jobs for our ever-expanding population and helped bring about the highest standard of living in the world."

Mr. Harder describes automation as "the intelligent and practical use of machinery" which has been the difference between up-to-date living and the primitive way of life so common to those countries relying on manpower alone. He notes that Ford's post-war program was designed to transfer to the machine wherever possible the physical burden and efforts of their employees.

He also cites a reduction in accident rate for which automation is partially responsible of 81 per cent since 1947. He notes that with more mechanization and automatic machines being installed in industry, skilled technicians will be in great demand. And skilled technicians will have more interesting work and better pay.

As to the general effect of automation, Mr. Harder says that "this new era of industrialization will not cause great or drastic changes in America overnight. It will be evolutionary in character and should have no abrupt or harsh impact upon our working population."

Automation has been proclaimed as something new perhaps to its own detriment. Union penalties on mechanization could stagnate industrial growth. It's time automation was recognized as a new name for something that has been going on since the first cave man cut a club—a better way to do the job.

where

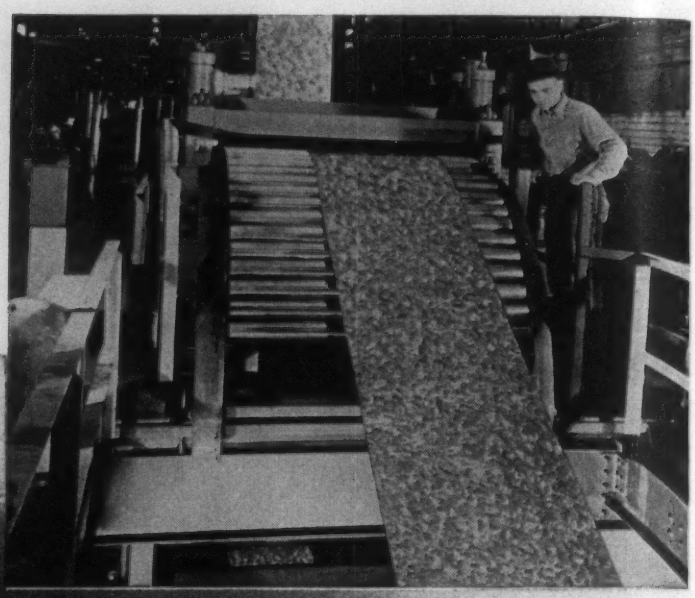
goes

AMERICA?

★ America must modernize its cities to keep up with a population growth estimated at 180 million by 1960. Every month we add to our population the equal of an Omaha, Nebraska; a Norfolk, Virginia; or a Toledo, Ohio.

Large scale building requires great tonnages of steel, copper, brass, aluminum, other metals, rubber and plastic. For example, a new office building under construction in New York will require 750 tons of sheet and strip for the air conditioning ducts alone. A remodeling of a Y. M. C. A. in our vision is taking 225 tons of steel. How much building is ahead? The year 1954 was the largest in history . . . 1955 is expected to be better.

Are your plants ready for volume production or are you handicapped by old equipment? **New equipment** brings **down production costs.**



Continuous Galvanizing obsoletes older methods. Aetna has installed 20 Continuous Galvanizing Lines and is constructing numbers 21 and 22. Will number 23 be yours? Other major Aetna products include Pipe and Tube Mills, [illegible] and Process Control Equipment; Machinery for Rubber and Plastics.

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GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

Successful Partnership

In the flurry of discussions concerning automation and its effects on the working man and his job, it is particularly important to study the industrial picture as it is today. Some factual statistics developed by the MAPI Council for Technological Advancement are most significant:

"It has long been assumed that as machines increased productivity, and as the demand for the goods and services of nonmanufacturing occupations grew by leaps and bounds with higher living standards, the proportion of the labor force in manufacturing would decline. The conditions prevailing in agriculture and mining have been expected to appear in manufacturing. Such has not been the case, however.

"In 1953 about 25 per cent of the total labor force was in manufacturing, about the same proportion as at the height of war production in 1944. In 1929 the figure was 21 per cent; in 1935 it was down to 17 per cent; in 1940 it was 19 per cent; and as recently as 1950 it was 24 per cent.

"Here is a particularly significant trend. First, it shows that employment in manufacturing has been rising—not only in numbers, but in proportion—even beyond the peak of Korean War production. Second, this increase appears in the area of the economy where automatic equipment and similar developments are being most rapidly introduced.

"The reason, of course, is expanding economic activity—the growing market for the manufacturing industries. Technological improvements stimulate that growth in a two-fold manner: (a) They increase the worker's output and hence his purchasing power; (b) They reduce production costs, and lead to lower prices or product improvements, or both."

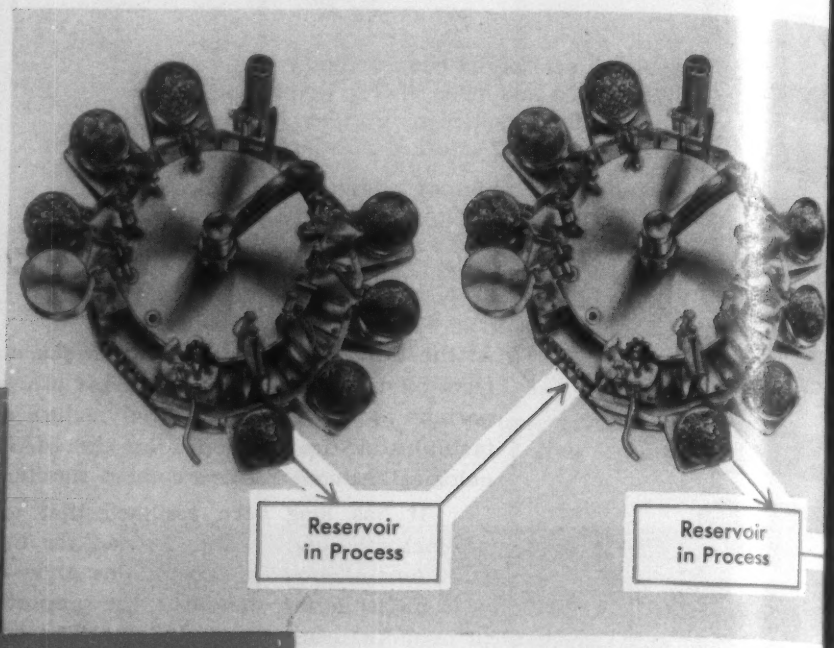
In the face of these facts it behooves every industrial worker to examine his position with regard to advancement into a more highly skilled occupational category. Company management and unions alike should be laying plans for effective training of workers for future advance into new jobs resulting from the introduction of automation. The need and obligation is clear.

Never before has there been such a challenging opportunity for advance. The successful partnership of men in industrial operations of the future may well depend on the understanding, insight and judgment exercised in meeting this challenge today.

H. A. Bolz

EDITOR

AUTOMATION



ASSEMBLY

By GEORGE H. KENDALL
and JERRY A. HOST
Consulting Mechanical Engineers
Darien, Conn.

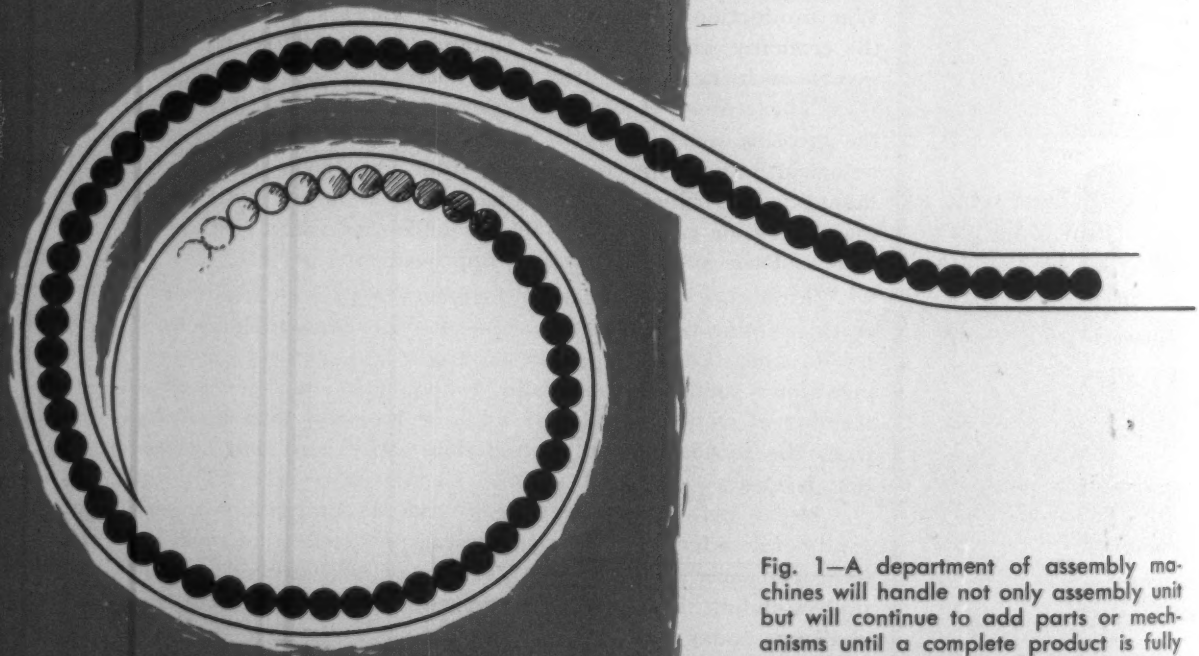
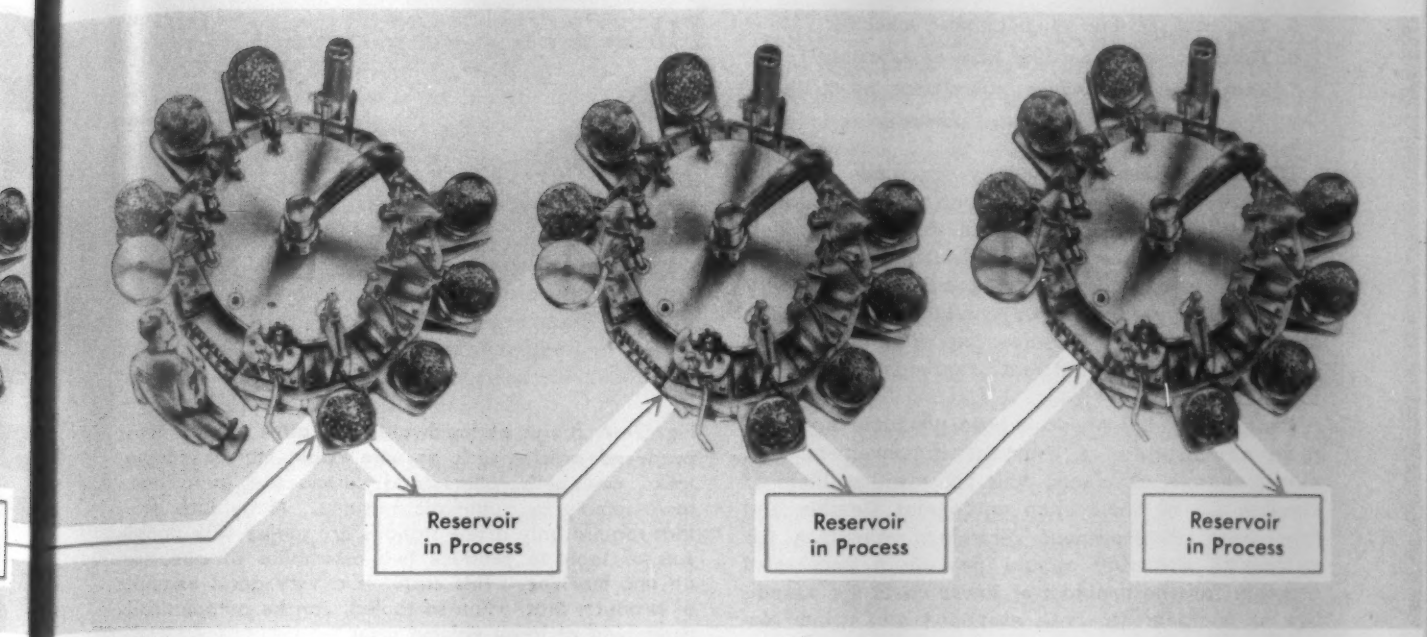


Fig. 1—A department of assembly machines will handle not only assembly unit but will continue to add parts or mechanisms until a complete product is fully assembled. This is usually accomplished through use of a battery of machines in which the work passes in progressive sequence from one to another machine. Work-in-process reservoirs are used between machines to store a sufficient volume of parts to enable continuous production in case of downtime on any one machine



BY AUTOMATIC MACHINES

Processing engineers are developing techniques of combining standard automatic machine elements—each designed to perform a specific function—into automatic production systems. Standard general-purpose assembly machines are taking their place in this automation movement. Considerations of machine assembly as opposed to hand assembly are herein introduced to management

MANAGEMENT HAS for the past 10 years been fully conscious of the need to do something basically to balance manufacturing operations against rising costs of production. A rapidly expanding market, production and quality demands, and limitations of hand operations brought about many studies in the field of continuous and special automatic process machinery throughout the country. As a result there has developed an enormous increase in the demand for automatic controls and mechanisms to operate the new process machinery. In the past few years the term "automation" has been applied to that field of machinery which was for the past 20 years referred to as continuous cycling special machinery and equipment.

The need became acute for automatic assembly machinery in those fields where no automatic equipment was commercially available. Many leading firms with experimental divisions of shop operating organizations have been developing special forms of such machinery for the past 10 years. Those firms not so fortunate as to have these facilities have tried initial steps of their own toward this end. The highly specialized engineering techniques required to handle such complicated problems, which involve a lifetime of study, have limited any great response to fulfilling this need.

Development of Assembly Machines

There are many types of assembly machines that have come into being over the past 20 years that serve single-purpose needs effectively for a wide field of different types of applications as follows:

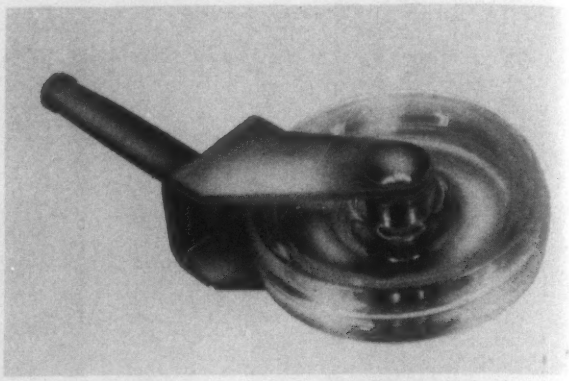
1. The straight line with individual workbenches.
2. The group bench line.
3. The long straight line of several groups.
4. The circular turntable with hand assembly.

5. The straight line semiautomatic machine.
6. The curved line bottling type of assembly.
7. The overhead conveyor intermittent bench line.
8. The circular fully automatic machine.

Finally, however, basic new machines for the automatic assembly of all kinds of component parts produced in volume have been developed. Such machines can be tooled and retooled for anything desired to be assembled. Management can now plan to realize the goal of major savings by machine assembly of products. This now makes understanding of the subject of sound and practical assembly by machines a must.

Progressive industries, whose products are in a most rapid state of constant improvement and model change, are faced with the vital problem of keeping all of their shop equipment flexible and free from obsolescence. Standard machines for automatic assembly should provide a successful solution for the problem of lower costs for assembly of components, both standard and other elements of special construction.

This article will outline the essentials for full automatic machine assembly of components, instruments or complete machines.



Courtesy, National Lock Co.

Fig. 2—A range of hardware and other similar mass produced articles such as wire cable clamps, hinges, locks, cow bells, pliers, and casters are good items for assembly by automatic machine. Many such items that require only a few stations are tooled with double sets of tools to produce two assemblies at one time on one machine. This caster is a very good example of products that, when so tooled, can be automatically assembled at large volume rates

Economics and Investment

There are many major economic gains possible through use of machine assembly. First, and most vitally important in reaching a larger market at reduced cost is increase in productivity per worker. Repeated applications suitable for mechanized assembly show increased productivity of from eight to twenty times that of former hand assembly.

Second, the quality and accuracy of machine assembly provides a rigid degree of uniformity never before possible in multiple hand operations. In fact, quality control of parts to be machine assembled requires rigid inspection to maintain all within established acceptable limits as the machine controls will otherwise stop operation.

Third, in any national emergency machine assembly enables immediate and adequate production for military requirements. Pilot tooling can be developed and tested on all new items to be ready for quantity output whenever required by an emergency. Assembly machines from any location can be immediately carried by plane to any place in the world where mass assembly needs exist. One assembly machine with one operator can assemble a ten-part unit averaging 20,000 assemblies per shift per day; or handling of 200,000 parts. Such basic assistance to the Military for electric, electronic and mechanical mechanism assembly cannot be overlooked.

Fourth, general-purpose machines for assembly of any kind of product can be purchased as capital investment of general shop equipment and written off over a ten to fifteen year period. The single-purpose machine or special machine carries the same classification as tools and fixtures which require writing off of their entire cost in not over two years in most cases for that kind of investment. This makes a difference in estimating for new equipment where the machine which represents one-third to one-half of the total cost can be written off over ten to fifteen years and only the remaining portion falls into the one to two year tooling category.

Fifth, the earning power of most shops requires the full immediate flexibility of all machines to be ready to produce anything that is to be made in the shop. The assembly machine, in keeping with other machine tools, can be changed from one to another set of tooling within three hours. The single-purpose machine or special machine has to be removed from the production floor and sent to a rebuilding shop to change from one to another limited degree of tooling or must be scrapped entirely.

Sixth, the enormous increase in productivity of an assembly machine over hand assembly operations saves about two-thirds of floor space for any given volume of production.

Seventh, assembly machines provide a basic economic operation of the same degree of importance in a department of manufacture as is held by lathes, milling machines, grinders or other such processing equipment.

Investment in assembly machines for a fully established department requires broad analysis and real investment in proper equipment, personnel, design or redesign of product for sound and practical machine assembly and in work lot scheduling, inventory and rate of turnover.

Really deep studies are needed to analyze investment in the size of lots produced at one time, inventoried, parts in process and warehouse stock in the light of multiple material handling of every part for every operation in manufacture. The

enormous savings, directly realizable as such, of automatic assembly are fully capable of changing ratios found best for hand assembly.

From this very brief outline it becomes clear that due to ever changing design of parts and processes, full flexibility to manufacture all items is essential for all equipment in an assembly department if equipment obsolescence is to be avoided. It also follows that special machinery, with its far greater first time build cost and limited degree of adaptability, will give way to basic standard machine tools, for machine assembly of all kinds of products. Where the standard machine tool is used, in case of product change, only the tooling investment is lost; not the entire machine.

The laws of probability and sensitivity to downtime point clearly to the value of unitized standard machine tools with work in process reservoirs between them for uninterrupted continuous production in the whole department.

The major savings from machine assembly are realized by assembling mechanisms of from 2 to not more than 10 or 12 parts per machine, and of additional machines for semifinal and final assemblies where so required. These savings are in the order of 80 per cent of all that it is ever practically possible to realize in normal production.

Attempts at placing more into one machine generally result in a rapid increase to excessive machine cost and a very real risk of spreading downtime to a larger unit of the whole production facility. Flexibility to handle a wide variety of shop assemblies is decreased by the oversized machine making it less attractive for a range of tooling and their excessively higher costs.

Those planning to set up departments of assembly machines should have an initial methods study made of a wide range of potential mechanisms for their products to determine the average, minimum and maximum number of operations for

TYPICAL SEQUENCE TOOLING FOR COMMON AUTOMOBILE CIGARETTE LIGHTER

(30 to 40 per minute)

1. SUB-ASSEMBLY SHELL AND DISC

Station #1—Feed "Bushing" into inner nest at work station nest

Index Station #2—Feed and orient "Shell" into outer nest at work station nest

Index Station #3—Feed and orient "Inner Disc" down into shell and over bushing at work station nest

Index Station #4—Stake bushing over disc at work station nest

Index Station #5—Lance "Shell" over outside of disc where specified (3 places) at work station nest

Index Station #6—Deliver to chute or container as specified by customer

Index

2. SUB-ASSEMBLY CONNECTION AND STUD

Station #1—Feed "Stud" and orient into work station nest

Index Station #2—Feed and orient other disc over square head on stud at work station nest

Index Station #3—Feed "Spring" over stud at work station nest

Index Station #4—Head over stud at work station nest to complete assembly

Index Station #5—Deliver to chute or container as specified by customer

Index

3. SUB-ASSEMBLY THERMAL UNIT AND TUBE

Station #1—Feed "Contact Shell" into one twin nest at work station. Feed "Paper Tube" into other twin nest at work station

Index Station #2—Feed "Square Insulator" into one twin nest over contact shell at work station. Feed and orient half "Spring Retainer" into other twin nest into paper tube at work station

Index Station #3—Feed "Disc" into contact shell at one twin nest at work station. Feed and orient other half "Spring Retainer" into other twin nest into paper tube at work station

Index Station #4—Feed and orient "Thermal Unit Shell" into one twin nest into contact shell at work station

Index Station #5—Stake the "Contact Shell" over the thermal unit shell at one twin nest at work station

Index Station #6—Transfer "Thermal Unit Assembly" into paper tube at other twin nest at work station

Index Station #7—Crimp "Paper Tube" at both ends at same time at work station nest

Index Station #8—Deliver to chute or container as specified by customer

Index

4. FINAL ASSEMBLY OF SUB-ASSEMBLIES

Station #1—Feed and orient "Sub-assembly Shell and Disc" into work station nest

Index Station #2—Magazine feed "Sub-assembly Thermal Unit and Tube" into "Sub-assembly Shell and Disc" at work station nest

Index Station #3—Hopper feed and orient "Sub-assembly Connection and Stud" into "Sub-assembly Shell and Disc" at work station nest and push down into final position

Index Station #4—Hopper feed and orient "Connector Sleeve" into "Sub-assembly Shell and Disc" at work station nest and push down and 1*st* crimp 3 lugs

Index Station #5—2*nd* crimp 3 remaining lugs

Index Station #6—Deliver to chute or container as specified by customer

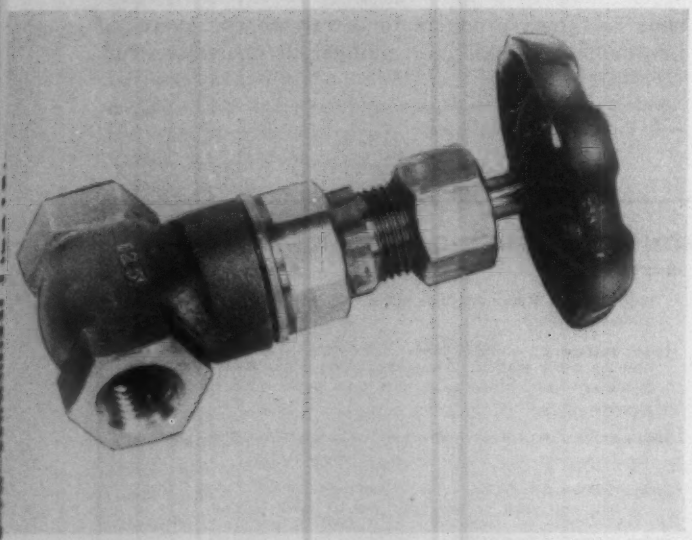
Index

Fig. 3—A typical example of automatic assembly using a battery of machines may be illustrated by study of a progressive sequence tooling for an automobile cigarette lighter of three mechanisms each of which is delivered to different stations on the fourth machine to assemble into the final complete product. On jobs of this kind much can be saved by careful design of product parts to assure tooling for simple machine assembly

each assembly that is involved. From this the proper number of stations of the standard machine for assembly can be successfully selected with the important assurance that the equipment will be kept busy after it is installed on the production line.

General-Purpose Machine

A machine assembly department for full general assembly of all company products must provide for the short run as well as the long run and continuous production items. Product model changes require that this equipment be kept fully flexible



Courtesy, American Chain & Cable Co.

Fig. 4—Normal assembly of a gate or globe valve is interesting in machine assembly as its assembled stem parts are turned to the "open" position to enable final nut assembly to the body to be tightened fully without damage to the valve seat. In some cases such a product can be effectively placed on two machines rather than to try to do too much on one machine

at all times to assemble all company products; otherwise the company is faced with expensive obsolescence of equipment.

It is of first importance to this subject, to clearly distinguish between standard and special machinery. It is generally considered that the special machine is primarily designed and built with its complete electrical controls to perform one-purpose application only. It has its tooling built into the machine, in a manner not flexible to changeover, and with neither the mechanical or electrical functions for handling other purposes. The standard machine is primarily designed and built complete to provide basic functions and controls for a whole range of applications within its capacity. It will not make anything, however, until tooled for each application.

A standard assembly machine can be arranged in stripped down condition, less all attachment tooling, so that it may serve on very short runs of one several hundred assemblies. A large-diameter table is used with operators seated around it with boxes of parts to assemble products as the table indexes. The group action assures fast paced assembly and has no tooling expense for handling, other than the work nests that hold the parts being assembled. This type of machine is ideal for all short or small run items up to the range of about 20,000 assemblies per run where the full automatic assembly machine with tooled attachments takes over on large-volume runs.

Additional automatic features can be added to the basic machine as production requirements warrant, such features include providing tooling attachments to handle, position and assemble the parts; compressed air and/or electric wiring connections at the work stations; electric sequencing or programming devices to interlock actions at the work stations. Only through use of portable, easily changeable tooling attachments can a department of assembly machines be sure of meeting demands to machine assemble all company products all the time.

Analysis of Products—Design

In the analysis of company products for the best degree of suitability of present design for machine assembly it is of first importance to top management that they secure a design analysis as to what could be done to improve design to lower manufacturing cost, simplify costs of hand or machine assembly and greatly lower costs of tooling and fixtures essential to produce and assemble the unit. There are many products in manufacture today where such attention could easily cut present costs in half.

Frequently, applications come to light where complicated hand assembly, or complicated compound slide machine assembly, could be almost entirely eliminated by simple design changes that would not alter function of the design in any way. This is particularly so where several subassemblies are to be finally assembled into the complete product.

To illustrate the type of thinking we might recall the first set of blocks almost all of us had as small childern where one was dropped within another to make the complete set. They dropped together by a simple single direction motion. They did not require side or cross motions of complicated assembly. In some cases we have forgotten these early basic lessons in sound and practical assembly and fearfully complicated structures have come into being which no sound reason can support: other than that not enough time was granted to the designer. In other cases this basic simplicity has appeared as illustrated by the radio tube, Cannon fittings, light bulbs, etc., that again show this basic trend of design.

Much of the cost of former electronic, electric and mechanical mechanisms will be avoided in future as leading design associations, research symposiums and trade conference papers continue to establish this trend for recognition of simple common sense by the designer to the problem of manufacture, assembly and servicing of the product he has under design.

▸ Analysis of Products—Volume

Research into the market essentials for automatic assembly to meet today's actual production problems seems to indicate the following points are of importance:

Production Quantity: The present business volume of standard component parts in production from many different industries indicates that a very large percentage of the whole market have quantities of 10,000 to 50,000 per production run, or per day of production. This includes the fields of electronic, electric, mechanical, toy, hardware, appliance, instrument, process, and chemical manufacture.

Repeat Volume: Many plants having these daily volume totals also may have such a variety that they are so cutting up production runs that an assembly size, or part change occurs every day from one to another item. The items, however, usually repeat as market demands dictate on a weekly, monthly or quarterly cycle basis providing support for tooling costs.

Product Change: In this present market there are many companies with production of simple component units of from two to eight or nine parts that are either national standards or free from style changes for many years at a time. Others in this market, such as the more new and recently established industries, like the electronic industry, are subject to a continual state of style and design change. This places major burdens upon manufacturing organizations to assure a full degree of flexibility of its facilities for manufacture of all company products.

Complex Design: Still others in this production market are manufacturers of more complicated mechanisms, machines or instruments that require a steady uniform rate of production over the years. Their problems consist of many subassemblies that are further assembled to make the complete product, machine or instrument.

Product Quality: In all of these fields of production the need for a more rigid degree of uniformity and freedom from the variables of the human equation are most evident. It is also of importance that the degree of uniformity of all of the parts be kept strictly within the established tolerances set as acceptable for the product.

It is clearly evident from this that any automatic assembly production problem will have a large number of ever changing variables in the production run both within and without the accepted tolerance limits. Most of them will be of dimensional nature of minute changes of size that may or may not affect assembly or later operation of the product.

TYPICAL SEQUENCE TOOLING FOR STANDARD GLOBE VALVE

(20 to 40 per minute)

Station #1—Feed "Fiber Washer" into work station nest

Index Station #2—Feed "Valve Stem" into work station nest over fiber washer

Index Station #3—Feed, from under work station nest, "Small Screw" and power drive through fiber washer into valve stem. Feed "Valve Body" into other twin work station nest location

Index Station #4—Feed "Bonnet" over stem and spin to bottom of thread at work station nest

Index Station #5—Feed "Valve Body Fiber Gasket" into location at valve body at twin work station nest location

Index Station #6—Transfer "Valve Stem" assembly into twin work station nest location into "Valve Body"

Index Station #7—Spin "Valve Stem" assembly into valve body with torque wrench tool to specifications

Index Station #8—Feed "Packing" over valve stem and push down to location at work station nest

Index Station #9—Feed "Packing Nut" down into position and push down at work station nest

Index Station #10—Spin "Packing Nut" with torque wrench to specification at work station nest

Index Station #11—Feed "Handle" onto valve at work station nest and press down to shoulder

Index Station #12—Feed "Brass Screw" into handle and power drive into position at work station nest

Index Station #13—Pressure check on valve at work station nest to customer specification

Index Station #14—Deliver rejected valves to chute or container

Index Station #15—Deliver accepted valves to chute, conveyor or container as specified by the customer

Index Station #16—Idle for the present. Would be used when "Drain Cap" item included after conference on tooling method questions

Index

Fig. 5—This tooling sequence illustrates a practical machine assembly arrangement of stations to do the whole job on one machine. Practical experience in machine assembly indicates that every fourth station should be a blank to provide a "breathing space" in the complication of machine assembly to assure the minimum of downtime: a basically important fact. Two machines for such an application would be a final recommendation

In general, machine assembly can be considered highly attractive if:

1. Parts are designed to go together well.
2. Runs of at least 25,000 can be scheduled at one setup time, or there are repeat run advantages.
3. Four or more operations are involved.
4. Two to 12 parts are involved in a mechanism (if more, use more machines).
5. Higher rates of production are desired.

Planning for automatic assembly will be covered in the second article of this series which will appear in the next issue.

REMOTE CONTROL

FEEDS DIE BLANKS

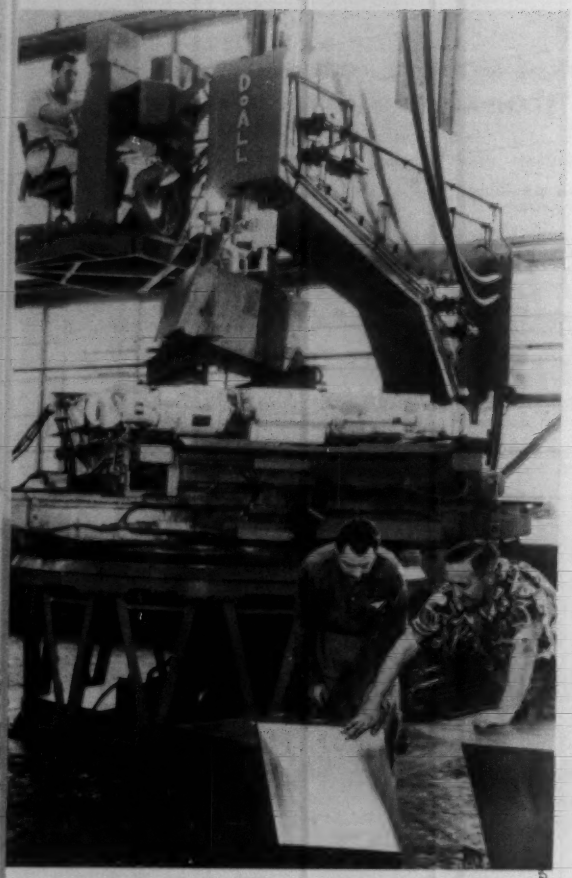


Fig. 1—Band saw at the Alcoa plant in Lafayette, Ind., built to manufacture the dies used in large aluminum extrusion presses

STRUCTURAL FORMS for aircraft, railroad car, bus, ship and similar construction can now be formed by the heavy-press extrusion process rather than assembled. Aluminum channels, spars and skin sections for aircraft are being extruded through the largest extrusion dies ever used by Alcoa.

Weight of die blanks (up to 10 tons) for this process makes manipulation difficult when sawing the die aperture. The machine tool solving this problem in the heavy press program is a large DoAll band saw that performs contour cutting of dies. A combined electric and hydraulic control system guides the blanks by remote control permitting the saw blade to cut along outlines of intricate, extrusion cross sections.

The operation is performed under control of an operator who sits in a station suspended from the head of the machine; height of this station is electrically adjusted over a 28-inch range and can be rotated manually through 90 degrees and swung out over the work surface. A close-up of the cutting action is seen by the operator through a periscope-like arrangement of mirrors. The operator steers the work along a designated curved or straight path with a control system that automatically co-ordinates the movements of three vertically stacked motor-driven tables.

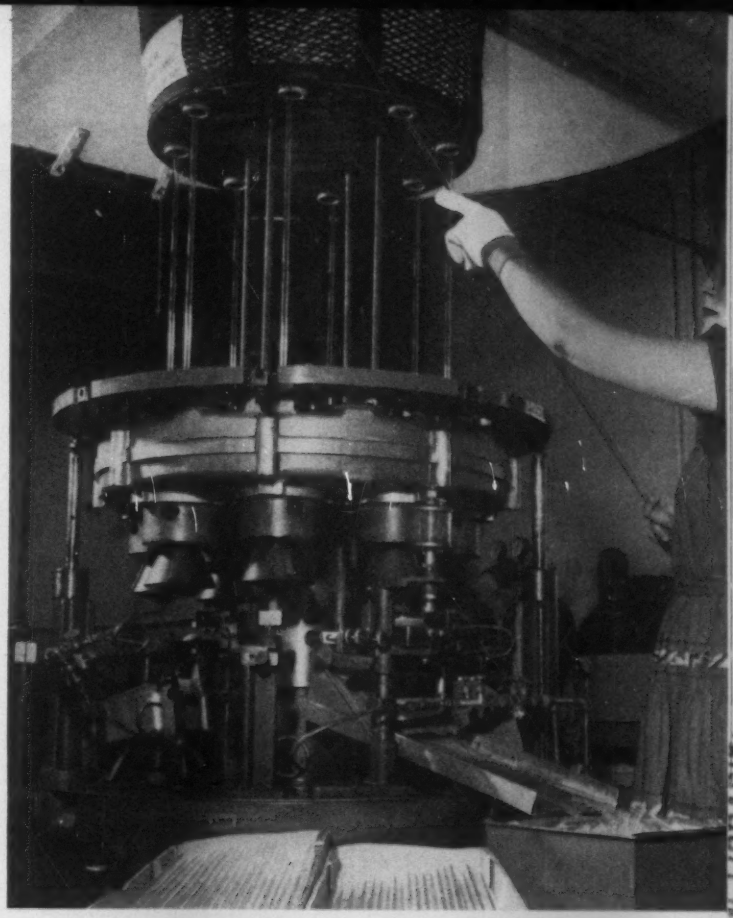
Controlling element is a steering wheel very similar in appearance and arrangement to that used by an aircraft pilot. To move the work into the blade the operator pushes the wheel forward; to retract the work he pulls the wheel toward him; and to stop all table movement he places the control wheel in a central position. To saw a curved layout line or a complete circle, the operator merely turns the control wheel to the right or left as required.

Fig. 2—Viewing the cutting action in a periscope-like arrangement of mirrors, the operator steers the work along the designated path with a simple wheel control

Because the operator does not touch the work during cutting operations, he is deprived of the sense of feel for evaluating cutting pressure, ease of cutting, rate of cutting, etc. This is compensated for with an indicating control system using strain gages. Not only is the operator informed of the pressure between the work and the saw band, but the system will maintain the pressure at the value set by the operator. Furthermore, there are automatic safety checks which stop all table feed motors if cutting and feed forces become excessive.

Saw blades 40 feet long are required having hardened teeth (60-65 Rockwell C) for rapid penetration and long cutting life, and a flexible back to withstand flexure over the band wheels. An automatic saw welder is used to join the saw blade into continuous loops for outside or inside cutting operations. Tool steel normally used for the die contains tungsten, chromium and molybdenum in annealed condition with 12-20 Rockwell C hardness. Savings effected by the contour sawing method are noteworthy since unwanted portions of the block are removed in whole sections, salvaging these pieces.

1



Glass tubes for mercury switches are cut to the desired lengths in this automatic crack-off machine. The operator has only to feed 4-foot lengths of the glass tubing into the machine. Brush flames and concentrated flames at seven stations scientifically bring the glass to proper temperature. At the final station a crack-off wheel, kept saturated with cold water, barely touches the glass tube. This action cuts the hot glass into lengths and is considerably better than the former method of breaking lengths off one by one after scoring on a cutting wheel

AUTOMATION TODAY

SWITCH IN MASS PRODUCTION

THE MANUFACTURE of precision mercury switches—a painstaking, laborious glass blower's art in most countries—is equally careful but far from laborious or slow in the United States. A new mass production system at Micro Switch Div., Minneapolis-Honeywell Regulator Co., speeds along portions of the manufacturing process with specially designed automation equipment. The new manufacturing techniques are designed to turn out better, more precise, more uniform switches at an economical cost. This mass production and resultant lower costs may well give the fluid contact switch a new stature.

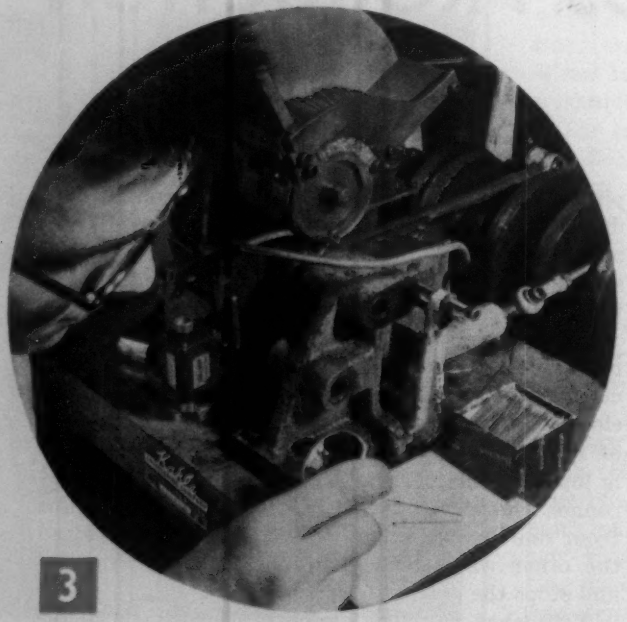
The mercury switch itself is a very common and widely used item and plays some role in virtually every kind of end product—in homes, industry, aircraft, ships, tanks, gadgets. Few homes in America are without from one to a dozen of these little switches; yet the average homeowner never knows they're around. They are specified for applications requiring silent operation, immunity to dust, moisture, gases, corrosion and other adverse surroundings, low operating force requirements and ability to adapt themselves to a simple tilting action.

The mechanism of the most common type of mercury switch consists of a sealed glass tube enclosing two electrodes and a pool of mercury. The electrodes protrude through the glass at one end of the tube. When the electrode end of the tube is lowered, the mercury slides to that end and surrounds the electrodes, permitting current to flow from one to the other. When the tube is tilted the other way, the pool of mercury moves away and stops the current flow.

A finished mercury switch is deceptively simple in appearance and operation for actually it has presented a parade of manufacturing problems that have plagued engineers. Forming and sealing the glass around the electrode wires and sealing the

W. W. Gilmore, president of Micro Switch Div., believes the new manufacturing techniques will spread the use of mercury switches. "This was an experiment at first," Gilmore said. "The ideas for the machines came from the firm's engineers at Minneapolis. Some of our own best brains were assigned to help work out details. Then with the aid of a custom designer of automatic glass working machines and techniques borrowed from the electronics industry, the machine line was set up. It is the first time that anyone has ever gambled with a heavy investment in automatic machinery to produce mercury switches."

2 To prevent cracking of the glass tube and obtain the best electrical contact with the mercury, each electrode is a fabrication of two types of wire. The high-speed percussion welder shown produces as many as 4000 welded electrodes per hour. Chrome iron wire feeds in automatically from a roll at left; molybdenum wire from the right. The machine cuts the wires to length; holds apart the ends to be joined until they are melted by an electric arc; then brings them together in a permanent weld



3 Special forming machine with automatic hopper feed makes an exact bend in the molybdenum end of the electrodes at the rate of 2000 parts per hour. Handled individually as previously done, about 200 pieces were formed per hour

opposite end of the tube has always been difficut. Inside portions of the switch must be absolutely clean at the finish of the manufacturing process, but contamination of glass, electrodes and mercury is difficult to prevent. Nothing but hydrogen gas should remain inside the tube with the mercury and electrodes; and the glass forming processes are critical with close timing essential. Human fingers, breathing and motion (stirring up cooling air movement) were often enough to ruin a hot tube, yet the damage would not show until the switch was completed and tested.

Consider the contamination problem of just one ingredient, mercury. Pure mercury is an absolute necessity for a good mercury switch. Triple distilled "commercially pure" mercury is not good enough for mercury switches. So it must be put through an additional lengthy purification process to eliminate oxides still present. Once it is thoroughly purified, mercury tends to amalgamate or combine with almost every substance around, and has to be kept isolated in air tight containers. When placed in a tube the mercury must be immediately surrounded by hydrogen so that it cannot oxidize.

It took years of struggling with the production problems before a mercury switch could be built to meet industrial standards. A gradual evolution has brought mercury switch manufacturing from laboratory glass blowing through single operation machines to improved automatic machines.

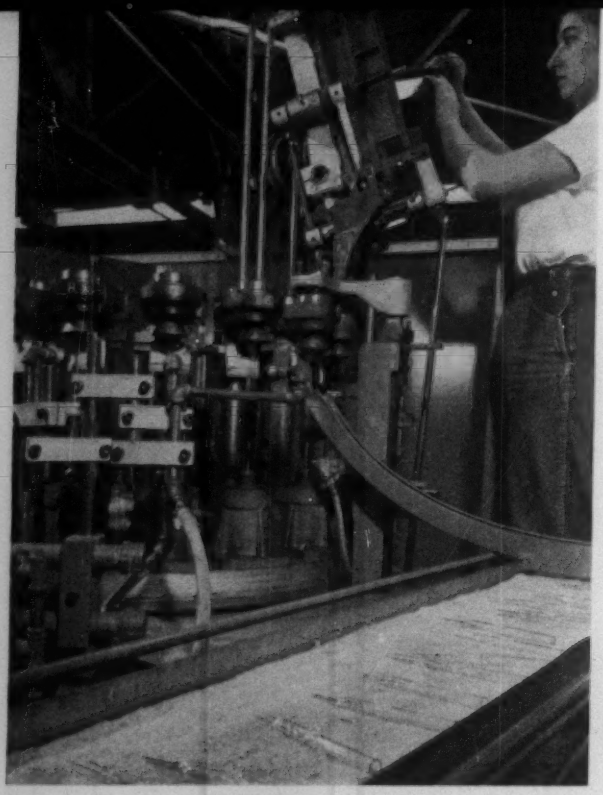
Though some special switch types will always be required to meet highly individual requirements, it is believed there'll be a trend toward standardization on fewer types. Whenever there's enough demand for one switch, it can be set up on the automatic machine line. That will mean a better switch at less cost.

4

Automatic sealing machine uniformly seals electrodes in one end of glass tube at a rate of more than 900 units per hour. Two operators manually place electrodes in the spindles. The glass tube is automatically fed into the machine from a hopper. Rotating through brush and concentrated flames, the tube is brought to proper temperature then quickly double press sealed. While in these stations, and while gradually cooling at the next few stations, the tube interior is filled with a gas under pressure to prevent oxidation of the electrodes. At station 24 a mechanical hand picks off the sealed unit and places it in a conveyor hopper which loads a belt-fed annealing oven

5

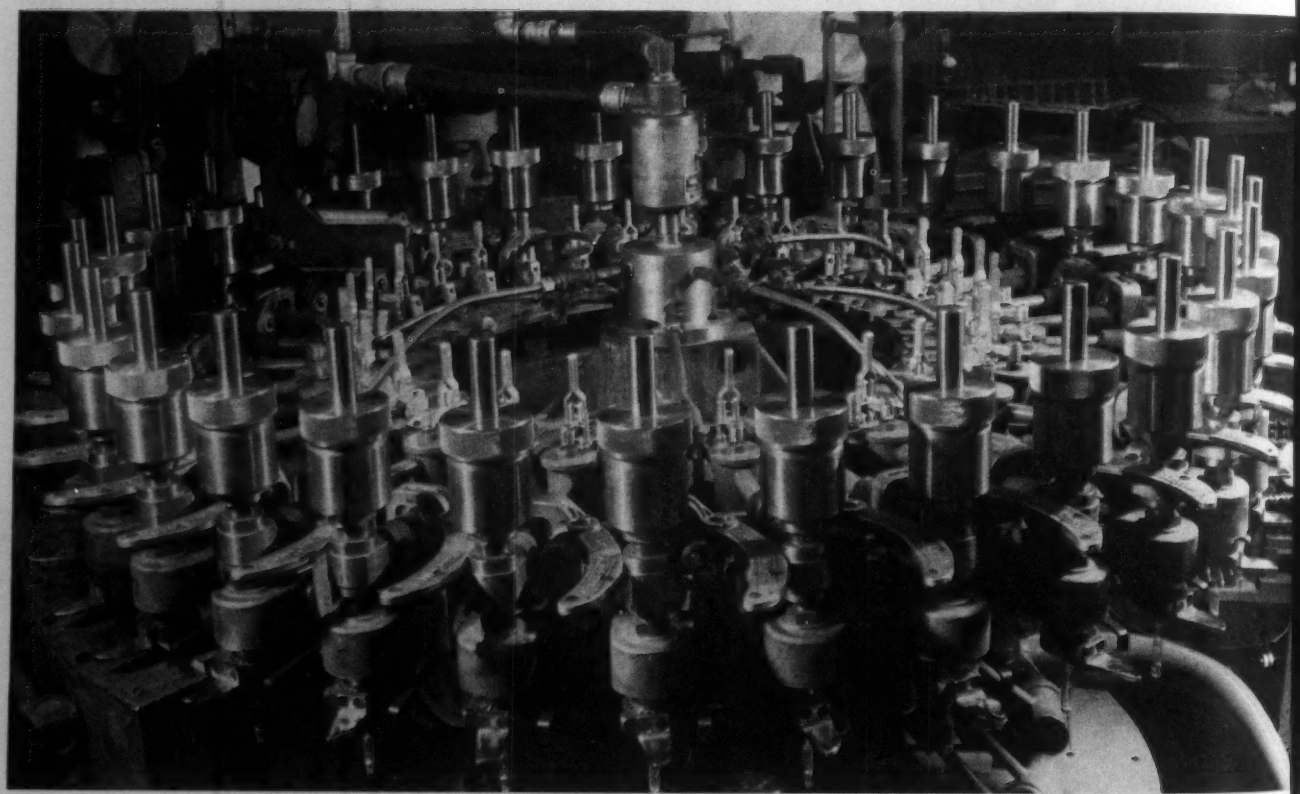
Accurate uniform positioning of electrode tips vastly improves switches. Watching blow-up of tube on screen, operator positions electrode tips to 0.001-inch tolerance with respect to wall of tube



6

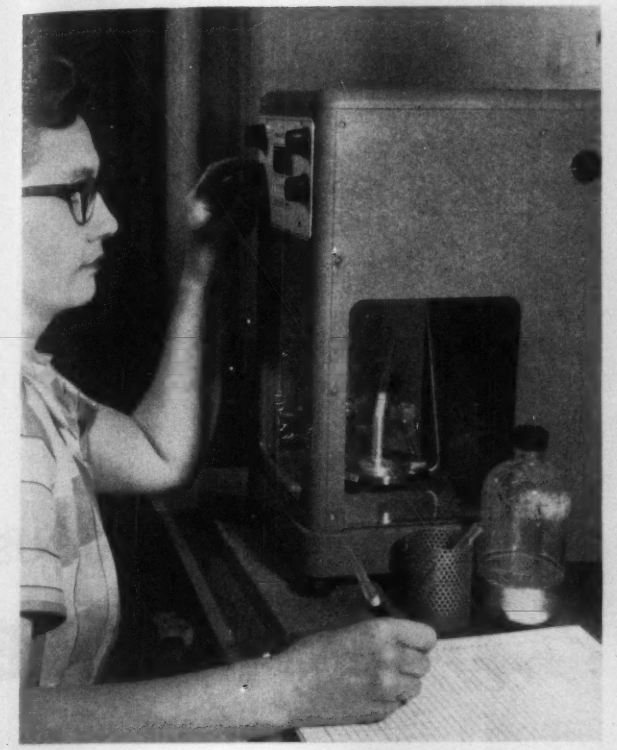
Fire and gravity are used to form a constriction at the point in the glass tube where final sealing will take place. The 16-spindle constrictor machine is automatically fed over 900 pieces per hour through hopper at upper right. The electrode-bearing tubes are brought to a precise heat by rotation through brush and concentrated flames. At a critical point the glass becomes molten in a predetermined area and the weight of the glass below causes the tube to sag and a constriction to form. Its temperature is gradually lowered and the tube is dropped automatically onto an asbestos conveyor belt. Mechanized handling has eliminated many problems formerly caused here by breathing on hot tubes, touching tubes, or otherwise suddenly cooling a particular tube area.

Tube units are then thoroughly cleaned, rinsed, and dried. Cleaning is done in a cyanide bath followed by several rinses in de-ionized water. After oven drying, the clean units are ready for filling



7

Pride of the new mercury switch production line is this automatic filling machine performing several operations which had not even been done semiautomatically. After a precise amount of mercury is dropped into it, the tube is washed out twice with pure hydrogen and then filled with hydrogen. Flames gradually close the tube constriction into an air-tight seal; the switch is broken off and drops into a chute while the unwanted portion of the tube is blown out of the chuck for remelting. This new machine fills over 800 switches per hour with a great reduction in the danger of contamination and at a lower cost than previously possible



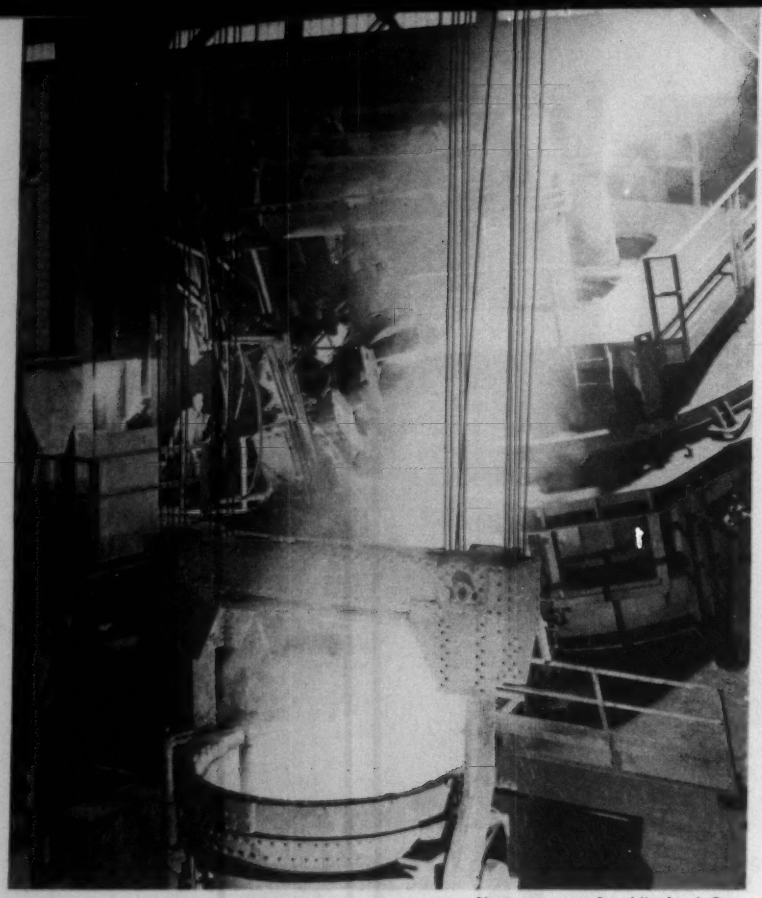
8 Inspector has full time job keeping tab on the precise weight of mercury dropped from each of the 32 heads of the filling machine. The automatic machinery now being used in this mass production line has created a number of new jobs like this one

9 Electroplating of electrode wires is automatic after operator loads and feeds racks of switches to the plating machine. Entire switch is submerged in plating tank since glass tube is unaffected

10 After preliminary testing and manual soldering of lead wires to electrode ends, the switches are given a final test in a device that tilts each switch slowly back and forth and records the make-break angle and accuracy and uniformity of switch action. This must be an accurate inspection since one type mercury switch operates on a movement of only slightly more than 1/10 degree. Mercury switches passing this final check are ready for use

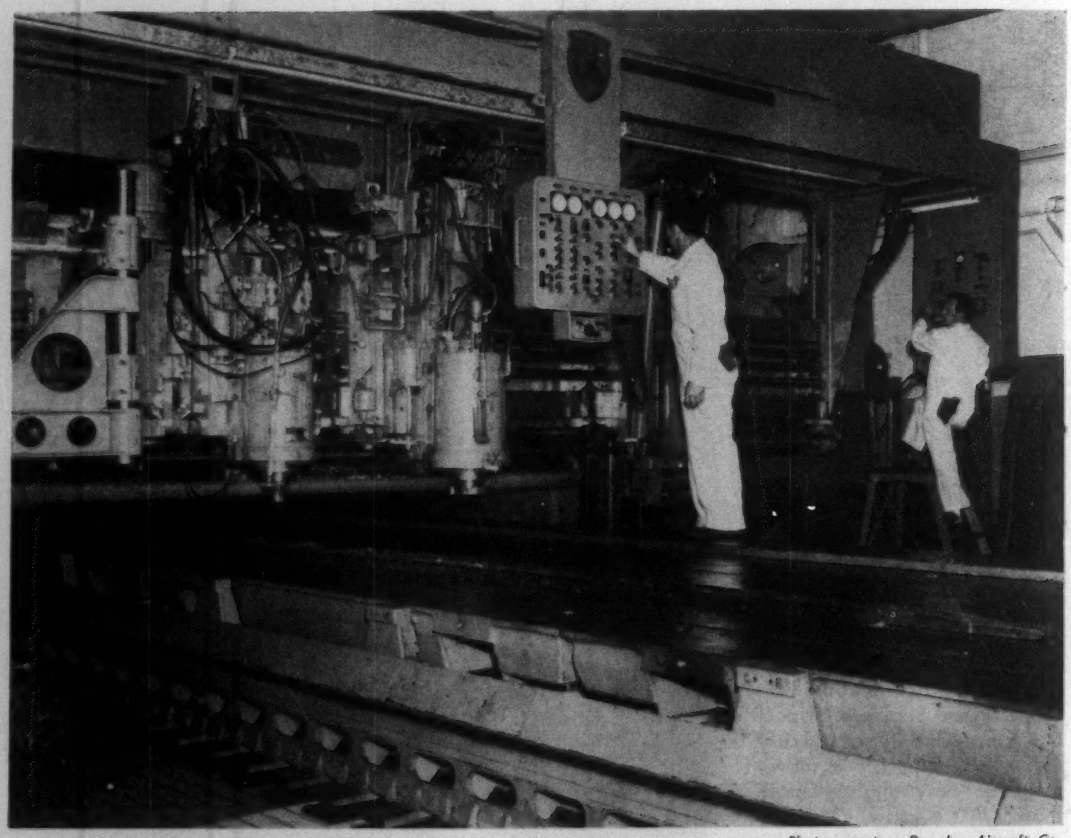
By HAROLD A. BOLZ
Associate Dean, College of Engineering
Ohio State University

CONTINUOUS MORE



Photo, courtesy Republic Steel Corp.

Maintenance . . . a major factor in the total manufacturing cost . . . deserves serious consideration



Photo, courtesy Douglas Aircraft Co.

Preventive maintenance pays but it cost money, too

"At our present mechanization and productivity level, we'd need close to 450,000 workers in 1964, a one hundred per cent increase, to meet predicted demand. But the best we can hope for is an increase of about 11 per cent in the national labor force. The only solution is more and more mechanization, and if our mechanization over the next ten years continues to increase at the rate it has increased in the last five—and we have every reason to believe that it will—we will double our productive capacity and with only 28 per cent more workers."—*From a paper entitled, "Maintenance to Meet Modern Industrial Needs", presented at the Cleveland Productive Maintenance Forum, by the General Electric Co., June, 1954.*

PROCESSING DEMANDS

EFFECTIVE MAINTENANCE

Only a critical appraisal and vigorous correction of the deficiencies of existing maintenance practices can provide the sound base on which to build an effective maintenance program to keep pace with increased automation. From the vantage point of advisor and co-ordinator of a maintenance panel conducted over a period of years for a group of prominent Midwestern concerns, the author examines the all important maintenance function

ANALYSIS of market trends and labor supply predictions will lead thoughtful executives to one important common conclusion—that it is going to take more and more automation to enable his business to hold its place in the competitive field of manufacturing during the years just ahead and as a corollary—that more automation means lower direct labor costs but it also means increased maintenance requirements.

In this connotation, more maintenance means not only increased maintenance labor hours but also higher levels of maintenance skills and techniques, and greater expenditures for maintenance organization and administration. The full significance of this needs to be emphasized since it is apparent that although maintenance is the preventive that keeps the mechanized plant alive and throbbing, unless it is properly controlled, it can easily become a toxin that will consume profits and weaken the business. The predictable importance of the maintenance function obligates the concerned executive to vigorously approach the task of reducing unwarranted maintenance costs.

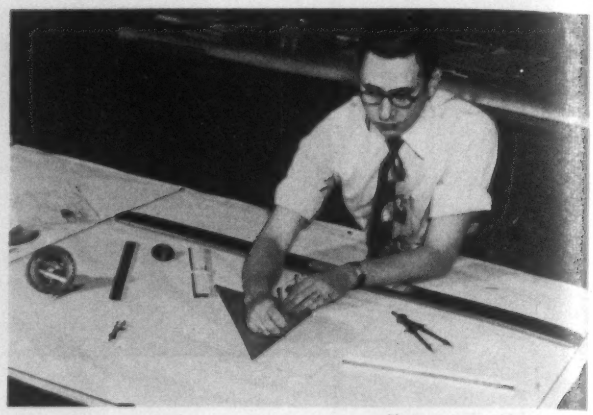
Approach To Cost Reduction

Maintenance costs can be reduced considerably in your plant if several points or principles are kept in mind and acted upon. These points are simple and almost obvious, the kind that keep "getting by" us with rather serious consequences. Let's examine them in the following form:

1. Maintenance constitutes a major factor in the total manufacturing cost of your product and, as such, deserves serious consideration.
2. Preventive maintenance pays but it costs money, too.
3. Economical maintenance requires sound organization characterized by strong administration, close supervision, careful planning, scheduling and control, and good co-ordination.
4. Maintenance cost reduction starts on the design board.

Everyone realizes that maintenance is an expensive function in any industrial enterprise. Fur-

thermore, everyone seems to believe that much can be done to reduce the cost of the maintenance function. Strangely, however, few companies know what their maintenance actually costs or what it should cost, and lacking this knowledge they have difficulty in planning, operating and evaluating a sound maintenance program. Estimates of maintenance expenditures range as high as six cents per dollar of total product cost but, since complete maintenance cost data are so rarely available in industry, there really are no adequate yardsticks for gaging maintenance effectiveness or needs. Manufacturing plants, like human beings, differ in so many immeasurable ways that cost statistics need very careful definition to be useful.



Photo, courtesy Armd Corp.

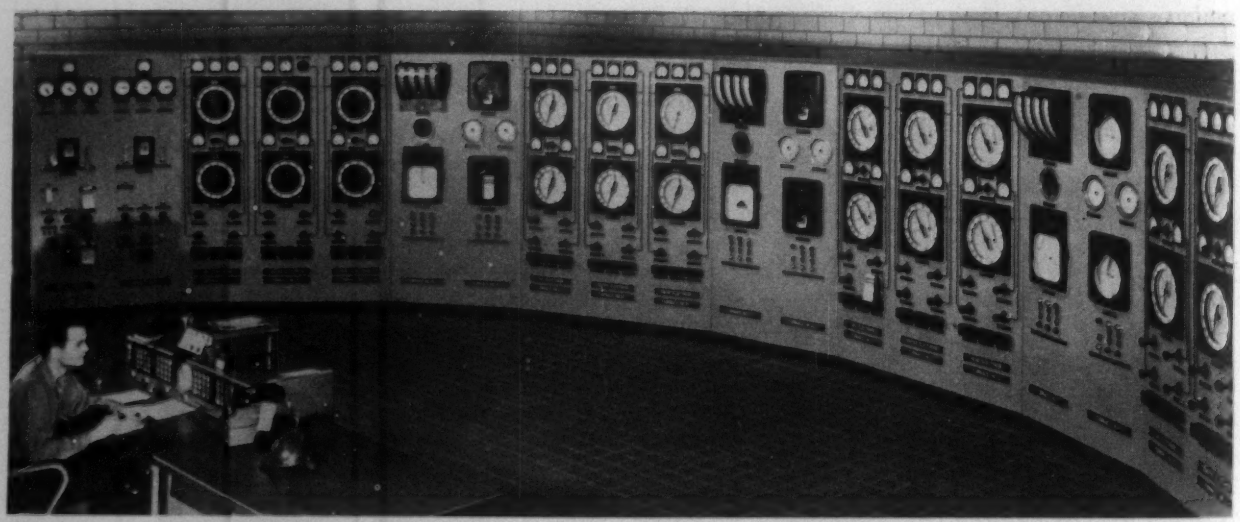
Maintenance cost reduction starts on the design board

Classification of Costs

In analyzing your maintenance problem are you sure that you are recognizing all of the elements that go to make up total maintenance costs? One way of classifying these costs is as follows:

1. Salaries and wages of maintenance staff.
2. Costs of maintenance materials and supplies.
3. Fixed and variable costs chargeable to maintenance equipment and facilities.
4. Downtime costs.
5. Scrap costs caused by processes in need of maintenance.
6. Shop modification costs.
7. Costs of redesigning equipment and product to reduce maintenance.
8. Cost of producing revised designs.
9. Safety hazard costs.

Frequently, a number of these elements are neglected in computing the total maintenance cost with the result that the true expense story is more serious than it is represented to be. Numerous instances have been encountered in which the annual cost of maintenance on a piece of equipment has exceeded the purchase price of that equipment. This is really serious. Reduced productivity, reflected in downtime and scrap losses, is a factor often neglected or minimized in computing maintenance costs. It is certainly more serious than obvious downtime losses usually indicate. The shock effects of emergency shutdowns and other maintenance interference on a production system are great but not readily measurable. The deleterious psychological effects on the worker who is expected to meet production schedules using maintenance-prone equipment no doubt reduce his working efficiency. Scrap produced by a machine in need of maintenance is as much a maintenance expense as the actual cost of performing maintenance.



Photo, courtesy Electro Metallurgical Co.

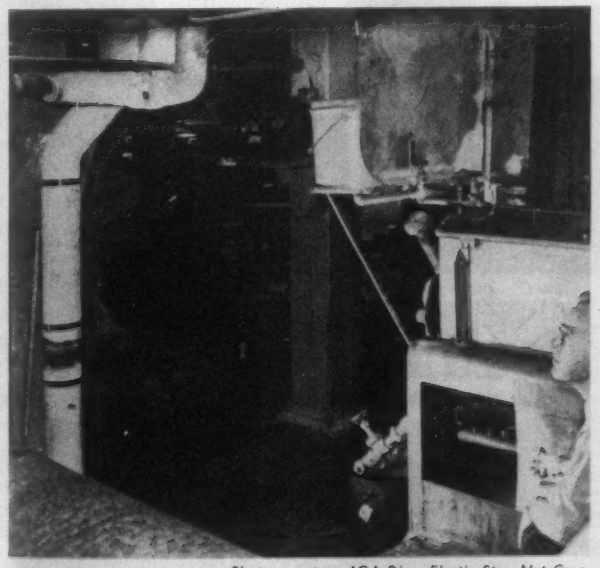
Maintenance function is fully as complex as the production system which it serves

When an accident-prone machine requires redesigning and rebuilding these costs, too, are really maintenance costs. Accidents, fires, and other hazards, either resulting from the want of maintenance or arising during the maintenance operation itself, incur costs which logically should be charged to maintenance.

Only when all of such charges as mentioned above are levied against maintenance, as they should be rather than be absorbed as factory burden, can the true costs of maintenance be determined. Every manager needs to ask "What is the cost of our maintenance?" The price of determining the cost accurately may not be justifiable; however, this problem needs careful study for it leads to an even more important question which management must answer, namely, "What should be the maximum cost of our maintenance?" The variation between the answers to these questions, however rough, will produce a good target for a vigorous maintenance cost reduction program.

▸ Preventive Maintenance Pays But

"An ounce of prevention is worth a pound of cure" is a good rule; but when the ounce of prevention becomes more expensive than the pound of cure, engineers must consider violating the rule. Under the latter circumstance it might be better to tolerate a few breakdowns than to spend excessively on preventive maintenance. Somewhere between "no maintenance until breakdown" and "continuous 100 per cent inspection avoids breakdowns" lies the point of best return for industry. Preventive maintenance has been defined as the "anticipation and prevention of breakdowns or major repairs through inspection, lubrication, planning and follow-up." This anticipation and prevention, as will be discussed later, should really begin with the design of the equipment involved.



Photo, courtesy AGA Div., Elastic Stop Nut Corp.

Preventive minded inspectors, alert to incipient troubles, are the real key to the success of any maintenance system

Photo, courtesy Chrysler Corp.

Economical maintenance requires sound organization . . . careful planning . . . and good co-ordination

The basis of a good preventive maintenance program is a carefully planned schedule of inspections, adjustments, replacements and lubrication. This planning must be done by engineers having a full knowledge of the conditions surrounding the equipment to be maintained—i.e., operating conditions, age and condition of the equipment, wear characteristics and maintenance requirements of each item, and the original cost of the equipment. Periodical routine inspections should always be supplemented by a complete check of important items and a replacement of worn parts during planned shutdowns or during shutdowns caused by reasons other than maintenance. It follows then, that planning for inspection should include the development of an adequate spare parts inventory and, in some cases, the acquisition of complete spare production units. All of these plans are dynamic in nature, rarely static or fixed, and must be revised continually as new information is gained from experience.

It should be noted that no adequate system of planning or effecting preventive maintenance is possible without complete records which furnish the following information: (1) Detailed maintenance required by each piece of equipment, (2) frequency of inspections, lubrications, and repairs to be scheduled, (3) condition of the equipment, and (4) costs of maintenance furnished to each

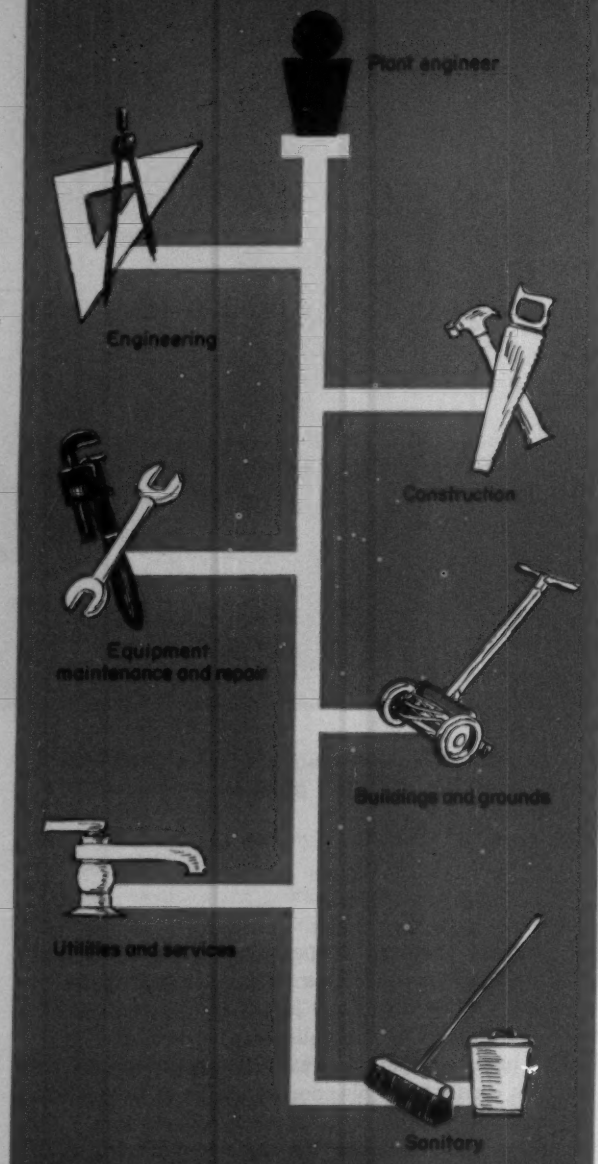


Fig. 1—Administration of maintenance by function

piece of equipment. An elaboration of the value of these records to the maintenance engineer and to management will be indicated in a later section.

▶ People "Make" the System

The success of any preventive maintenance program is often considered to be based on careful planning. Nevertheless, any system, however well planned, is effective only if operated by conscientious, well motivated personnel. Consequently, preventive minded inspectors, alert to incipient troubles of any type and in any area, are the real key to the success of any maintenance system. Inspectors of this caliber may also serve in valuable ways as co-ordinators, as liaison between shop and office and as advisors because of their interest in the preventive philosophy of maintenance. But if properly carried out, preventive maintenance pays because it accomplishes the following:

1. Keeps equipment running longer.
2. Minimizes maintenance and repair costs.
3. Shortens shutdowns and avoids unscheduled shutdowns by anticipating troubles before they happen.
4. Provides spare parts when needed.
5. Changes maintenance from an emergency operation to a planned, organized procedure.

▶ Maintenance Administration

The maintenance function is fully as complex as the production system which it serves. Consequently, the organization of maintenance requires as much attention as the organization of the other

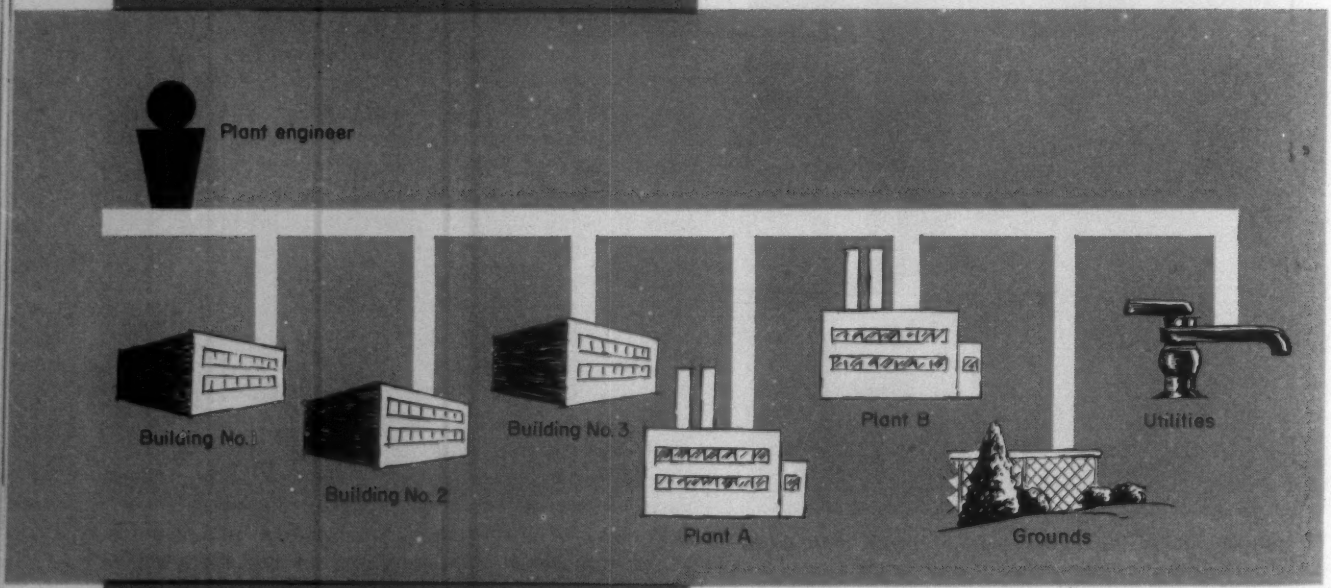


Fig. 2—Administration of maintenance by area

Table I

Prime factors which influence the type of administration and supervision for a particular plant are:

1. Size of plant.
2. Nature of layout.
3. Nature of product.
4. Type of equipment.
5. Union limitations.
6. Quality of supervision available.
7. Training facilities available.

functions such as sales, finance, etc., if it is to be of optimum effectiveness. This means that administration, supervision, planning and scheduling, control, co-ordination, and records must be *carefully tailored to suit your particular manufacturing situation,* TABLE 1.

Whether the responsibility for all maintenance administration is placed under one functional group or whether the maintenance responsibility is administered by each plant area is a problem to be solved individually by each company. Plant-wide administration by function, *Fig.* 1, provides a pool of specialists, each involved in a narrow variety of work which is relatively easily supervised. It facilitates plant-wide standardization of methods, work measurement, and records; and probably provides better control over manpower and functions. Administration by plant area, *Fig.* 2, requires broader capabilities of its personnel, allows less specialization but develops more flexibility of manpower and permits closer co-ordination and supervision. Area responsibility encourages a team spirit, or area loyalty, which is priceless in getting difficult jobs done in emergencies.

▸ Maintenance Supervision

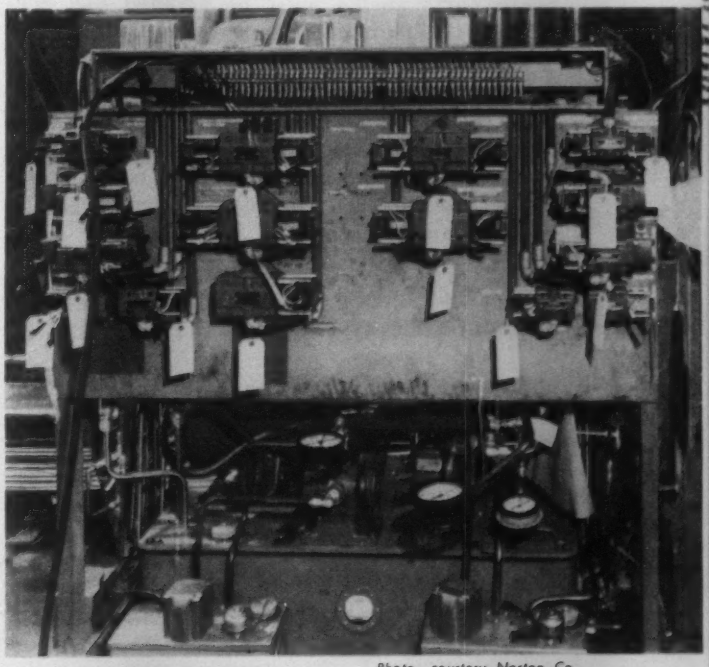
The actual assignment and supervision of maintenance work may be done by skills (hydraulic, electrical, mechanical, etc.) or by equipment or process classifications (punch press, heat treat, power plant, assembly, etc.); but here again the decision depends upon the individual characteristics of the organization concerned. Supervision and performance by skills usually provides more flexibility for small plants having light equipment and special technical requirements. It engenders better union relations. One of its main advantages is that it gives the foreman a better chance of being recognized as the master expert by his men since his group handles a limited range of operations. In small plants, particularly, full co-ordination among the separate groups engaged in maintenance is possible.

Generally, however, even better co-ordination among the technical trades is obtained when maintenance supervision is by plant or production area. Here responsibility is centralized and all skills working in an area answer to the same supervisor. Less time is lost between skills working on a job and maintenance effort can be more concentrated. Furthermore, the cost control system is simpler when all maintenance personnel are confined to an area. Such personnel too, are likely to develop an area loyalty that provides a stronger incentive than would exist if their efforts were spread over the entire plant. It must be recognized, however, that the comparative effectiveness of administration and supervision by one method over another is so largely dependent upon the human factors involved in the plant concerned that no quantitative comparisons between companies can be made with any degree of reliability. Each company must analyze its total situation as a special case.

▸ Planning and Scheduling

In establishing a schedule of maintenance activities it must be recognized that there are several distinct types of work to be planned for. These are:

1. Scheduled or preventive maintenance (inspection, lubrication, adjustments, replacements).
2. Scheduled minor construction, installations, and alterations.
3. Scheduled heavy construction and alterations.
4. Emergency or corrective maintenance, unforeseen repairs.



Photo, courtesy Norton Co.

Emergency maintenance, unforeseen repairs . . . destroys the effectiveness of many an otherwise well-planned program

It is this last type that destroys the effectiveness of many an otherwise well planned program. Breakdowns will occur under the best system of preventive maintenance. In fact, the ideal system includes a calculated risk of breakdowns because perfect insurance against breakdowns can be justified only in extreme cases. The following reminders may be of help in organizing a new maintenance schedule system or in re-evaluating an existing system.

It is usually cheaper to put up with minor breakdowns than to *pay the price of excessive preventive inspection.* The break even point must be determined for each class of equipment in its particular operating environment.

Many minor repairs, adjustments and *replacements can be made simultaneously with routine inspections* to reduce downtime and repetitive disassembly and reassembly operations.

It is economical to have technical trade *groups make certain inspections outside their respective fields* while making their routine inspections. For instance, the electrician inspecting the motor driving a ventilating blower can check the filters while he has the housing open.

Orders for repair and inspection should be specially written and *costs itemized only for jobs above a certain magnitude.* Smaller jobs, (such as those involving less than three man-hours of labor or fifteen dollars total cost) should be handled and reported routinely without special orders or requisitions.

It is usually economical to have the *same skills handle small construction jobs* as would perform the inspection and repair on such items.

Good scheduling includes *careful planning of shutdowns* of equipment for inspections, repair and replacement.

Spare parts *stocks must be planned and controlled* if the maintenance program is to be effective. Where warranted, complete spare production units should be provided.

Maintenance *must be dynamic.* Manpower commitments and availability *must be balanced* in preparing schedules—and kept balanced continuously as situations change from day to day, week to week, and month to month.

▶ Importance of Follow-up

Maintenance schedules, however well planned, will be of continuing effectiveness only if the scheduled jobs are followed up. This means checking up on performance time against hours scheduled, manpower and materials utilization against allocations, and particularly on quality of work accomplished. The purpose of the follow-up is dual—to determine the effectiveness of both the scheduling and the maintenance operation, with the objective of improving both and at the same time reducing costs.

The maintenance foreman is generally the best person to be given this follow-up responsibility. His crew should be small enough to allow him to maintain close inspection of the quality of their performance. It has been suggested that statistical quality control of maintenance operations might be developed to advantage in this respect. The foreman's load should be planned to allow him enough time to maintain adequate contact with the maintenance engineer and others concerned with the analysis and control of scheduling, work standards, costs, parts inventory, etc. Adequate contact implies meetings, properly organized and conducted, to effect full exchange and recording of ideas.

▶ Co-ordination of Maintenance Work

Good control of the maintenance function is attained only through close co-ordination of all personnel and activities involved. This co-ordination must start during the design of the machinery, equipment and facilities to be maintained. Designers must have the advice of shop men if they are to design maintenance-free equipment. The same is true of those responsible for purchases of equipment. Co-ordination between manufacturing and maintenance departments must follow then as a continuing requirement for minimum maintenance cost. Maintenance inspectors in some plants prove to be excellent co-ordinators between these two groups because of their plant wide contacts. As a further means of co-ordinating maintenance considerations with other phases of plant activity, maintenance representatives should sit with all committees concerned with product planning, plant layout, methods improvement, safety, etc. In turn, representatives of these areas should have appro-

Table II

Ten steps and precautions to be taken in establishing an effective wage incentive plan for maintenance employees.

1. Establish the best work methods.
2. Set sound standards of work performance.
3. "Sell" the employees on the methods and standards adopted.
4. Control the methods used.
5. Control the work orders.
6. Make accurate work measurements.
7. Establish a sound incentive plan.
8. Maintain complete and accurate records.
9. Include 100% of all craft hours spent.
10. Maintain and manage the plan thoroughly through the cooperation of industrial engineers, maintenance employees, supervision and management.

Table III

GOOD PROCESS OR MACHINE DESIGN FOR MAINTENANCE

Should be easy and safe to:

- move and install
- set up
- operate
- adjust
- inspect and check
- lubricate
- repair
- clean and paint

Should be free from breakdown or malfunction because of:

- failure of parts
- faulty lubrication
- inadequate cooling
- changes or drifts in adjustment

Should afford maximum protection to machine, product and operator in event of breakdown

priate positions on major maintenance committees. Maintenance bulletins or news letters, patterned after commonly used safety letters, are helpful in developing maintenance-mindedness on the part of all personnel.

Within the maintenance department itself, of course, co-ordination among the various skills is essential and is a major function of planning and supervision.

Incentive Plan Is Possible

There is nothing about maintenance work that makes it impossible to apply incentives successfully. There are factors which make incentive plans seem difficult to apply but certain plants have shown that incentive plans can be made to work in maintenance, TABLE 2. If we define incentives as a means of increasing productivity by means of rewards, the problem becomes primarily one of standardization and work measurement. Whether an incentive plan is employed or not, standardization of maintenance methods and maintenance work measurement is desirable. In fact, this is necessary to assure minimum maintenance costs in any plant. The nature of the incentive plan to be adopted and the degree of success likely to be met depends upon the same factors which influence the type of administration employed.

Value of Records

Incentives, standardization, measurement, cost control, co-ordination, scheduling, and supervision all depend upon good records of maintenance activities. The basic form is the equipment record which should include:

1. Purchasing and installation data.
2. Dated inspection data.
3. Complete maintenance, repair and replacement history including costs.
4. Maintenance manuals and catalog information.

Planning and schedule forms, work orders, inspection check sheets, parts and supplies requisitions are other paper forms which supplement the basic equipment record. Records are essential in:

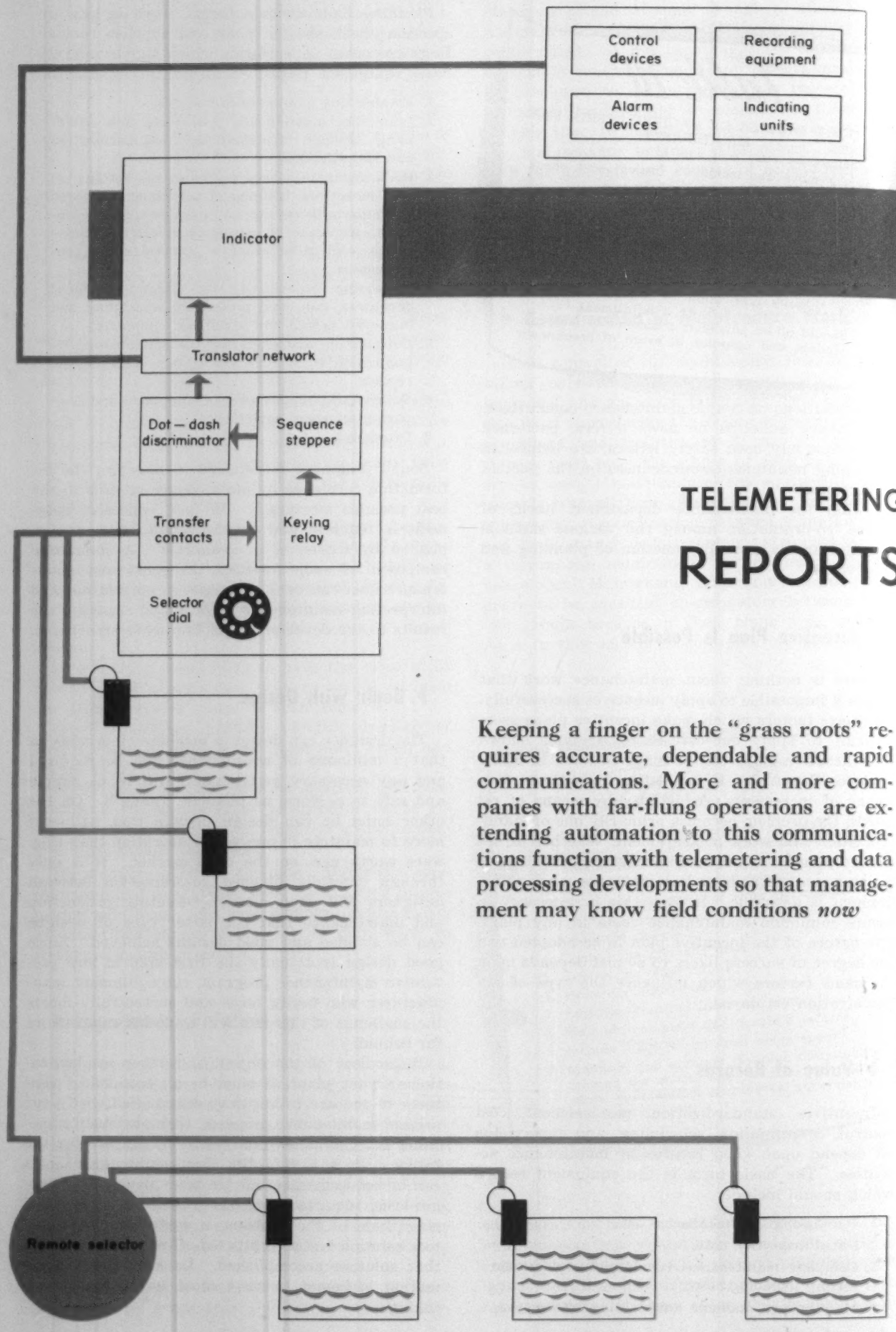
1. Establishing maintenance budgets.
2. Improving maintenance procedures and scheduling through systematizing, standardization and simplification.
3. Reducing maintenance costs through better control, incentives, training of personnel, improved spare parts inventory, improved design of equipment, disclosure of causes of excessive maintenance, and stimulation of general costs consciousness.
4. Increasing productivity by effecting reduced downtime, improved production scheduling and improved design and layout of equipment.
5. Determining and justifying the maintenance organization, equipment, and system, including the records.
6. Determining replacement of equipment and comparing alternate equipment.
7. Promoting safety.

Sound judgment is required to interpret the information furnished by maintenance records to the best possible advantage. In fact, collective judgment is required and this is usually best accomplished by means of a committee. A committee composed of shop foremen, designers and maintenance men can be a real asset in correlating and interpreting maintenance records and applying the results to the development of improved procedures.

Begin with Design

The designer can design a machine or process so that a minimum of maintenance will be required and any necessary maintenance will be as simple and safe to perform as possible, TABLE 3. On the other hand he can design devices that will cost more to maintain in one year's operation than they were worth new on the open market. It is only through carefully planned co-ordination between designers and shop men representing production and maintenance that the latter type of designs can be avoided and good designs achieved. Since good design is actually the first step in any preventive maintenance program, the equipment manufacturer who really faces and successfully meets the challenge of this fact will leave his competitors far behind.

Regardless of the object of further mechanization in your plant, it must be an economical venture; if you are in any way dissatisfied with your present maintenance program, then obviously something must be done—and soon—to prepare for the future. It is a safe bet that maintenance costs can be reduced materially in your plant. To do so, however, requires a serious realization of the real magnitude of the problem, a systematic approach to a solution and co-ordinated effort toward getting that solution accomplished. Lacking these, automation is bound to be a most hazardous undertaking.



TELEMETERING REPORTS

Keeping a finger on the "grass roots" requires accurate, dependable and rapid communications. More and more companies with far-flung operations are extending automation to this communications function with telemetering and data processing developments so that management may know field conditions *now*

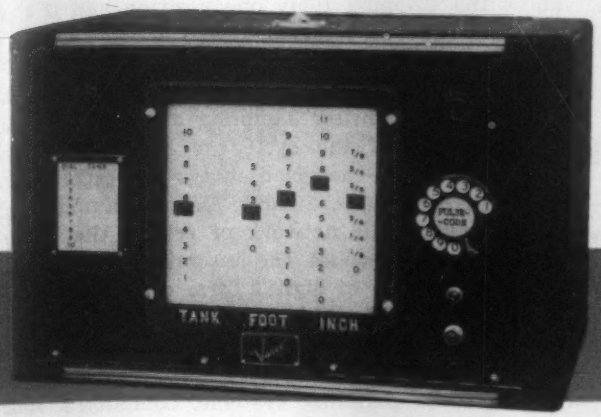


Fig. 1—Readings in ⅛-inch increments of liquid levels are shown visually on indicating panel in this receiver. The operator's report selection device is mounted to the right of that panel in this design

SYSTEM

REMOTE LIQUID LEVELS

PRECISE DATA, continuously available on widely separated conditions existing at the moment are of increasing importance to industry. As one specific answer to this need, a pulse code telemetering system has been applied by the Vapor Recovery Systems Co., to accurately report liquid level readings from several petroleum storage tanks to a central point. Precise reports on liquid levels are available in a few seconds to operators, recorders, or controllers at distances up to hundreds of miles from the storage facilities. The system consists essentially of a gaging device, a transmitter, a communication link, and a receiving device.

A single receiver may be used to selectively report liquid levels from several tanks with each tank having an individual gaging device, transmitter, and communications link with the receiver. Where a group of tanks is located at some distance from the receiver, a remote selector unit can be located near the group of tanks to selectively transmit reading signals from the individual tank transmitters to the distant receiver. Use of the remote selector unit is not necessary for the basic operation of the system, and so it is not discussed in detail here, but it can be used to greatly reduce the number of communication links required where tank grouping is such as to indicate a need for it.

Each reading report is initiated at the receiver end of the system by selection of the tank from which a reading is desired. In the unit illustrated, this selection is made manually by an operator using apparatus similar to the dial telephone.

When the selecting process has been completed, the receiver is linked to the individual tank transmitter by some type of communication link capable of conveying long and short pulse signals; such as a metallic pair, a single wire and ground, or any type of carrier system operated over existing telephone lines, or microwave. An advantage of pulse code systems is that almost any communication channel may be used. The pulsing speed is low and the amplitude, phase, frequency or polarity have no effect on the intelligence, so that line resistance, voltage variations, frequency shift, and circuit mismatch have no effect on the signal over wide variations.

Furthermore, in this particular system for petroleum tanks, each ⅛-inch increment of liquid level is represented by an arrangement of dots and dashes which is a separate and distinct pulse code entity in itself. Partial codes or groups of codes are not used. Loss of any part of the signal or gain of any extraneous signal parts will produce a signal that has no meaning to the receiver. Due to the unique arrangement of the code, the receiver unit can sense whether a bonafide signal has been received and can ignore a false signal and indicate no reading.

The automatic tank gage used is float operated. As the float rises and falls with the liquid level, a perforated steel tape attached to the float trans-

mits this motion to a sprocket sheave and provides shaft rotation proportional to the liquid level. The input to the transmitter unit is this mechanical displacement in the form of shaft rotation.

In the transmitter, *Fig.* 2, two code disks are connected by gearing to the input shaft. One of the disks is for inch increments of the liquid level, the other for foot increments. Each code disk has seven code tracks on its surface and a contact brush for each track. The contact between the brushes and the code disk segments is determined by the position of the disk as based on the liquid level indication from the gage. The transmitter contains a motor-driven sampling switch to sample the code disk brushes and thus the code disk position. During the gaging cycle the sampling switch sequentially contacts each of the code brushes. Each position on the sampling switch corresponds to a possible contact position on the code disks, and as the sampling switch revolves, a pulse is transmitted for each of these positions. If for a given position, the associated brush is not in contact with a segment on the disk, a short pulse (dot) is transmitted, and if the brush is in contact with a disk segment, a long pulse (dash) is transmitted.

In addition to the liquid level code signal, the transmitter is arranged to transmit a tank code signal indicating to the receiver which tank is being gaged. This is accomplished by using up to seven of the sampling switch positions for tank number code. These positions are wired to a terminal strip so the coded tank number can be set as desired. At the end of the gaging cycle the transmitter stops and the system is ready for the next tank selection or reading.

Input to the receiver, *Fig.* 1, consisting of pulse signals from the transmitter, drives a stepping relay circuit to provide sequence synchronization with the transmitter and also a dot-dash discriminator circuit. Each incoming pulse received advances the stepping relay one position and if the pulse is a dash, as determined by the discriminator circuit, a code relay is energized and locked up.

There is one code relay for each of the corresponding transmitter sampling switch positions. At completion of the cycle the arrangement of energized and de-energized relays corresponds to the telemetered tank number and the liquid level in that tank. This network of relays, the translator network, decodes the incoming signals and reports that data in digital form compatible with latest developments in data handling and the trend toward increasing automation. This allows the output of the translator network to be fed into various types of data handling systems, computers, indicators, printing systems, warning systems, and supervising systems, without the need for auxiliary conversion equipment.

The petroleum tank system shown illustrates the use of this translator output to give visual readings by lighting lamps behind a screen on an indicator panel. This system also provides that the indication will remain on the panel until released by the operator, a provision which could easily be altered.

Through use of unit type construction, the equipment in this system is adaptable to custom built systems. Special control consoles can be constructed around the components; the selector dial and indicator panel may be mounted on an operator's panel with all other components located at a distance; or the selector dial only may be on the operator's desk with the indicator mounted in an instrument panel; or various other arrangements may be used.

Pulse code systems are not limited, of course, to liquid level telemetering. With a code arrangement such as used in this petroleum tank system, pulse code systems can be designed for reliable remote supervisory control of motors, valves, or other equipment, and to feed information to automatic or semiautomatic, data processing centers.

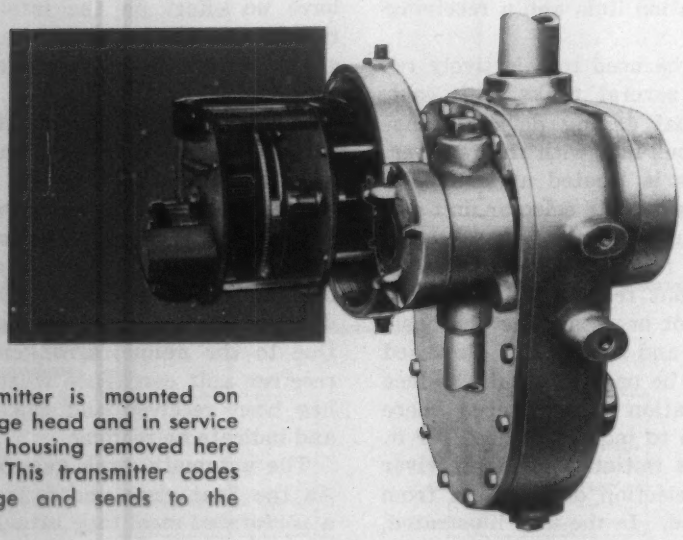


Fig. 2—Compact transmitter is mounted on standard liquid level gage head and in service is totally enclosed by a housing removed here for better illustration. This transmitter codes the output of the gage and sends to the receiver

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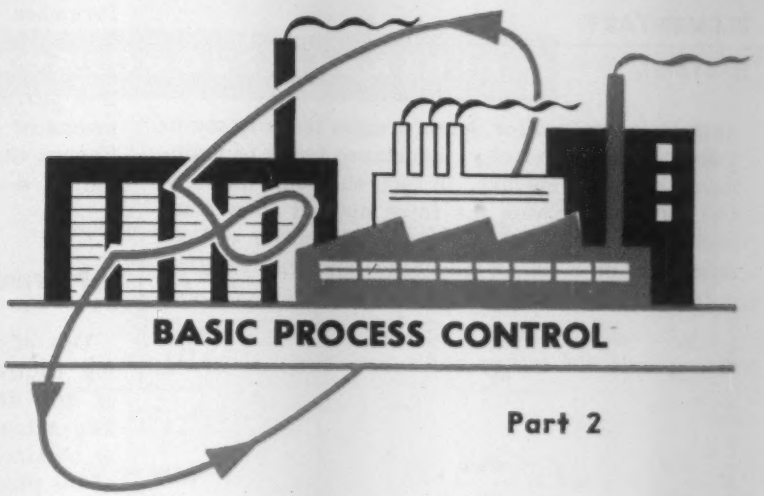


Part 2

ANALYSIS OF ELEMENTARY SYSTEMS

Process control is not the domain of any single branch of engineering. How then, can an engineer hope to extend his understanding in so broad an area? This article will improve dexterity in applying the transfer of energy concept common to all systems to minimize difficulties in unfamiliar fields

PROBLEMS involved in control systems cover the full range of invention, analysis, design and testing in all fields of engineering. The design problem of an automatic control system involves consideration of the transfer of energy throughout the system, considered dynamic since its response is described by differential equations obtained from basic physical relationships. In order to understand automatic control one must be familiar with the basic laws of energy transfer in physical systems and their application to engineering problems.

Physical principles underlying many electrical, mechanical, and thermal phenomena are essentially the same since all special laws of energy transfer pertaining to a specific phenomenon are drawn from basic premises—the most important of these being the law of conservation of energy (total energy of an isolated system remains constant and cannot be changed in any way) and Newton's third law (for every action there is an equal opposite reaction.) Kirchoff's laws governing electrical phenomena, Fourier's law governing heat flow, and the familiar Ohm's law are extensions of these basic laws of energy transfer.

In general, the analysis and design of feedback control systems must be carried out on a mathematical basis in order that time may be saved in reaching optimum design. This implies that all the physical elements which constitute the control system must be described in some mathematical form before their contributions to system performance can be related satisfactorily to determine the overall system response.

Broad Engineering Approach

Expressing each system component mathematically is facilitated by the many interesting parallels between characteristics of mechanical systems and those of electrical circuits. The similarity between mechanical mass of inertia and electrical induct-

ance is recognized for, while a mass tends to maintain a constant velocity, inductance tends to maintain a constant current. In fact, the same differential equation relates the force applied to a mass and the resulting velocity, as relates the voltage impressed on a linear inductance and the resulting current.

$$M \frac{dv}{dt} = f \text{ and } L \frac{di}{dt} = e \quad \ldots\ldots (1)$$

or

$$M \frac{d^2x}{dt^2} = f \text{ and } L \frac{d^2Q}{dt^2} = e \quad \ldots\ldots (2)$$

The minus sign has not been used in the electrical equation because e represents applied rather than induced voltage, the two being equal and opposite.

In a similar way, viscous damping in a mechanical system can be considered analogous to resistance in an electrical circuit. This can be seen by comparing the expressions for damping force and for voltage across a resistance.

$$Dv = f \text{ and } Ri = e \quad \ldots\ldots (3)$$

or

$$D \frac{dx}{dt} = f \text{ and } R \frac{dQ}{dt} = e \quad \ldots\ldots (4)$$

The compression of a spring and the charge on a condenser are expressed by similar equations,

$$kx = f \text{ and } \frac{Q}{C} = e \quad \ldots\ldots (5)$$

or

$$k \int v dt = f \text{ and } \frac{1}{C} \int i dt = e \quad \ldots\ldots (6)$$

Basically, the analogy of mechanical, thermal, hydraulic, and pneumatic systems with electrical systems rests upon the similarity of mathematical laws which govern mechanical motion, heat transfer, fluid flow, and electron flow. Early papers by Baker and Paschkis[1] have done much to develop the analog method of obtaining analytical and experimental solutions used quite successfully in analog computer work on automatic control systems. TABLE 1 summarizes the electrical and analogous units which are generally covered in the analog treatment.

Analogies serve a number of useful purposes. Their most common use is as an aid in visualizing relations in an unfamiliar type of system by reducing it to more familiar terms. They are of aid in calculation, for if two systems are rigorously analogous, their solutions are analogous also, permitting theorems and solutions that have been built up in one branch of engineering to be extended to problems in other branches. This fact furnishes justification for the techniques of analyzing mathematically a complete control system composed of many types of components. Finally, if a particular type of result is desired, while the means of obtaining an analogous result is already known, the analog may be an extremely suggestive aid in devising the proper system.

[1]References are tabulated at end of article.

Transient Response Fundamentals

One of the most important factors in determining control performances is that the full effect of any disturbance is not immediately obtained. The actual response of the system or component is obtained from the basic differential equations of the physical system, commonly called a transient analysis, and is necessary whenever a complete analysis of a control system is required. This response depends upon the characteristics of all the components in the system and is known as the dynamic response of the system. Characteristics upon which the response of the system depends are known as the dynamic characteristics. Types of responses of physical systems may be classified and rules for their treatment have been established by mathematical laws.

Those basic performance criteria which are established from a transient analysis are:

1. Speed of response, which is a measure of the time required for a system to reach approximate steady state conditions after an upset.
2. Maximum overshoot, which is the maximum amount by which the actual output exceeds the desired output during transient conditions.
3. Frequency of system oscillation.
4. Steady-state error, which is the difference between the actual and the desired output after the system has reached a steady state.

Quantitative meaning of these terms will be more readily understood as the subject of automatic control is developed. They are defined at this point in order to establish justification for the dynamic study.

Analog Approach

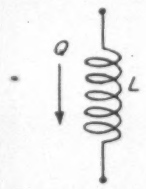
As an illustration of the manner in which the responses of physical systems may be classified, response of the output pressure to an input disturbance of the process shown in *Fig.* 1 will be derived. Instead of a direct solution which may be achieved through use of well-known hydraulics formulas, the electrical-analog approach will be used for simplicity.

In setting up the analog, it is obvious from the diagram that the electrical equivalents are resistive and capacitive elements. Therefore, based upon the analogies shown in TABLE 1, and assuming a linear system, the electrical analogous circuit shown in *Fig.* 2 may be intuitively obtained. The dynamic-equilibrium flow equations may be written

TABLE 1—ANALOGOUS ELEMENTS

ELECTRICAL ELEMENTS

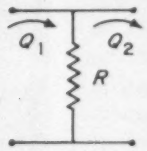
Electrical inductance



$$E_L = L\frac{d^2Q}{dt^2}$$

L = Inductance

Electrical resistor

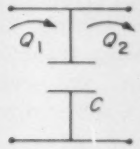


$$E_R = R\frac{d(Q_1 - Q_2)}{dt}$$

R = Resistance

Q = Charge

Electrical capacitor

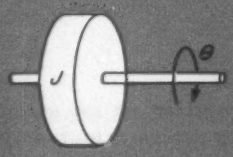


$$E_C = \frac{1}{C}(Q_1 - Q_2)$$

C = Capacitance

MECHANICAL ELEMENTS (Rotational)

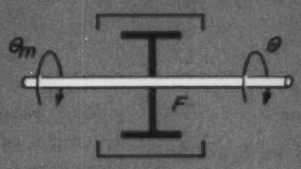
Inertia



$$T = J\frac{d^2\theta}{dt^2}$$

J = Moment of inertia

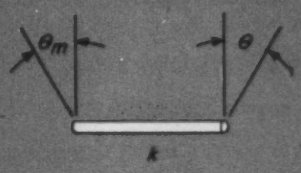
Torsional damper



$$T = D\frac{d(\theta_m - \theta)}{dt}$$

D = Damping coefficient

Shaft stiffness

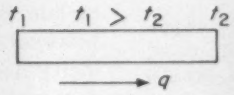


$$T = k(\theta_m - \theta)$$

k = Stiffness coefficient

THERMAL ELEMENTS

Thermal resistance



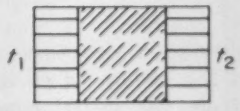
$$q_T = \frac{t_1 - t_2}{R}$$

q_T = Heat flow

t_1, t_2 = Temperature of bodies

R_T = Thermal resistance

Thermal capacity



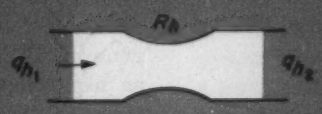
$$Q_T = C_T(t_1 - t_2)$$

C_T = Thermal capacitance

t_1, t_2 = Temperature of bodies

HYDRAULIC ELEMENTS

Fluid resistance



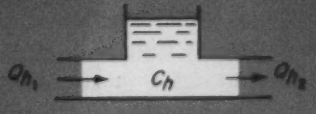
$$F = R_h q_h = R_h \frac{dQ}{dt}$$

R_h = Hydraulic resistance

Q_h = Quantity of flow

$Q_h = Q_{h_1} = Q_{h_2}$

Fluid capacity



$$F = \frac{Q_1 - Q_2}{C_h}$$

C_h = Hydraulic capacity

Q_{h_1} = Inflow

Q_{h_2} = Outflow

for the hydraulic system and its electrical analog to prove the validity of the *Fig.* 2 analog.

Response of the output voltage which is analogous to the output pressure of the hydraulic system is obtained by writing the differential equation defining the energy transfer characteristics of the electrical circuit. By writing a nodal equation about point *a*, a differential equation is obtained.

$$\frac{e_{in} - e_o}{R} = C\,\frac{de_o}{dt} + i_2 \qquad (7)$$

However, if the impedance of the instrument or meter which is used to measure e_o is high, the current i_2 may be neglected.

By separating variables, Equation 7 may be rewritten as

$$RC \int \frac{de_o}{e_{in} - e_o} = \int dt \qquad (8)$$

Integrating Equation 8 gives

$$-RC\ ln\ (e_{in} - e_o) = t + K \qquad (9)$$

where K is a constant of integration and *ln* denotes a logarithm to the base ϵ.

From the definition of logarithms, Equation 9 may be rewritten as

$$e_{in} - e_o = \epsilon^{-\frac{t}{RC}+K} \qquad (10)$$

This can be rewritten as

$$e_o = e_{in} - K\epsilon^{-\frac{t}{RC}} \qquad (11)$$

In order to obtain a particular solution, K, which arises from the constants of integration, must be evaluated from the initial conditions. If the assumption is made that a step input, such as shown in *Fig.* 3, is made to the process at the time $t = 0$, then $e_o = 0$. This is then substituted into Equation 11 to yield

$$e_o = e_{in}\left(1 - \epsilon^{-\frac{t}{RC}}\right) \qquad (12)$$

Equation 12 is the complete expression of the output voltage as a function of time, a plot of which is shown in *Fig.* 4.

Transform Method Expedition

Solution for the response of the output voltage was obtained using the so-called classical method of solution. For more complicated systems it can be seen that such a solution will become more involved. A solution will be made for the transient response of a mechanical system to introduce a method which greatly simplifies the mathematics.

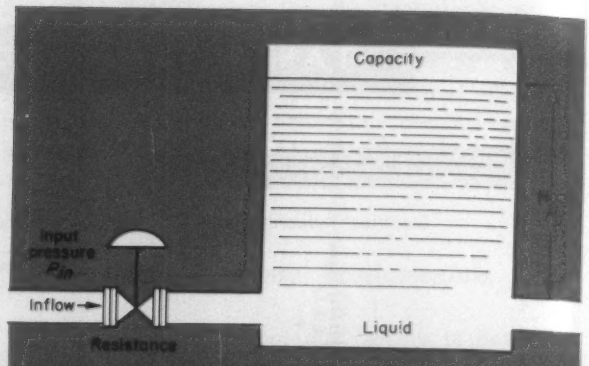


Fig. 1—Single-capacity hydraulic system showing input disturbance resulting in an output pressure. This response is called that of a "first-order" component referring to the order of the differential equation which describes the energy transfer characteristics of the component

The mechanical system to be analyzed, *Fig.* 5, consists of a spring whose input may be rotated through an angle θ_m and whose output end has vanes which are assumed to require a torque proportional to their angular velocity v. It is apparent that the introduction of a twist to the input angle θ_m stores energy in the spring by stressing it. This stored energy causes the output end to turn through an angle θ. Immediately following the introduction of a disturbance to θ_m, the angular velocity v is initially high because the spring torque is high. As the angle of twist decreases, however, the torque decreases, and thus the velocity decreases. The output angle approaches the new value of θ_m at a diminishing rate which is proportional to the angle of twist remaining.

This characteristic of the system will be established mathematically. By equating torques and using the relations shown in TABLE 1, the differential equation for the system is found to be:

$$k\ (\theta_m - \theta) = D\,\frac{d\theta}{dt} \qquad (13)$$

This equation has the same form as Equation 7 obtained for the electrical circuit of *Fig.* 2. In general, differential equations of the same type as Equations 7 and 13 have two solutions, steady state and transient. However, the systems used as examples in this discussion are assumed to have zero initial conditions which means that the steady-state part of the solution will be zero. For instance, in the mechanical system example the spring is initially unstressed and, after the transient dies out, the spring returns to an unstressed condition. Under this assumption the equations obtained may be solved by determining the roots of the characteristic equation and evaluating the

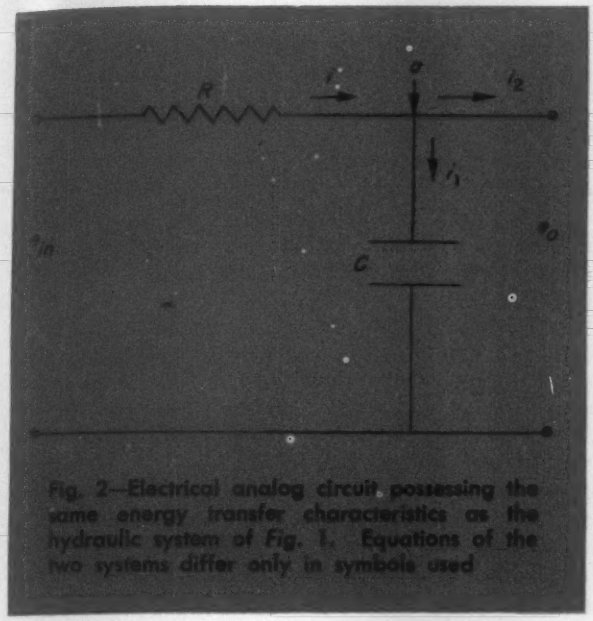


Fig. 2—Electrical analog circuit possessing the same energy transfer characteristics as the hydraulic system of *Fig.* 1. Equations of the two systems differ only in symbols used

constants of integration by means of the boundry conditions.

It has been shown previously that the transient solution of Equation 7 takes the form of $A\epsilon^{st}$, where A depends upon the initial conditions and s is a function of the parameters of the component. This time, instead of integrating the differential equation to find the response, a solution of the form $\theta = A\epsilon^{st}$ will be assumed. Therefore, the characteristic equation of Equation 13 is

$$0 = k A \varepsilon^{st} + D \frac{d(A\varepsilon^{st})}{dt} \quad \ldots\ldots (14)$$

which becomes

$$0 = A \varepsilon^{st} (k + Ds) \quad \ldots\ldots (15)$$

This equation will be satisfied if

$$k + Ds = 0 \quad \ldots\ldots (16)$$

The root of this equation becomes $s = -k/D$, and the assumed solution $A\epsilon^{st}$ satisfies the differential equation for the value $s = -k/D$.

From this example it can be seen that substituting s for the differential operator d/dt yields the same form of response as was obtained by the classical method of solution. The next logical step is to develop this method so as to be of practical use in making a complete transient analysis.

Assume that the characteristic equation of the response of a component has the form

$$0 = s + \alpha \quad \ldots\ldots (17)$$

and $\alpha = 0$, which is a special case where the slope of the response curve is infinite—the final value of the response is obtained instantaneously. Assuming the response again takes the form $A\epsilon^{st}$ its response as a function of time will be, assuming zero initial conditions,

$$f(t) = A \varepsilon^{0t} = A \quad \ldots\ldots (18)$$

This expression plotted against time is in the form of the step input curve shown in *Fig.* 3.

If the procedure is reversed, exactly the same differential equation will be obtained. This can be done by solving the expression

$$U(s) = \int_0^\infty A \varepsilon^{-st} dt = \frac{A}{s} \quad \ldots\ldots (19)$$

The minus sign is used to signify that the exponential response is a decaying one which is true for most physical systems. Notice here that the root of the characteristic equation is equal to zero as originally assumed. This operation is known as taking the transform of the response as a function of time and is the defining equation of the LaPlace transform method.

This definition may be extended to more complicated equations. The transform of the response obtained in the preceding example is found as follows:

$$U(s) = \int_0^\infty \varepsilon^{-\frac{kt}{D}} \times \varepsilon^{-st} dt = \int_0^\infty \varepsilon^{-\left(s+\frac{k}{D}\right)t} dt \quad \ldots\ldots (20)$$

Solving

$$U(s) = \frac{1}{s + \frac{k}{D}} \quad \ldots\ldots (21)$$

Note that the denominator of Equation 21 is the same as the left side of Equation 16. It could be obtained directly by substituting s for the differential operator d/dt.

This transformation is known as the LaPlace transform method and is used to change from the time domain, in which the dynamic behavior is expressed in the differential equation, to a functional domain, in which the differential equation is expressed as an algebraic relationship. These functional expressions can be manipulated by the laws governing ordinary algebra, even though the variable is more complex in nature. After the original tranformation, certain manipulations known as inverse transforms enable return of the dynamic problem to the time domain, but in such a manner that the solution to the original differential equation has been obtained.

Actually, this is an oversimplification of the LaPlace transform method. Those who are interested are refered to Gardiner and Barnes[2], for a comprehensive treatment of the subject.

Use of transforms is not peculiar to the realm of higher mathematics. In simple arithmetic the common logarithm is used to transform numbers into powers of ten. By this means, the problem of multiplication is changed to the much simpler

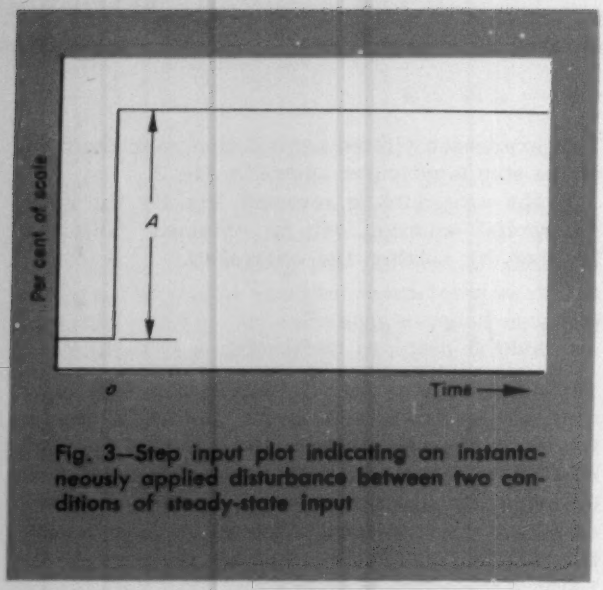


Fig. 3—Step input plot indicating an instantaneously applied disturbance between two conditions of steady-state input

one of addition. If it is desired to find the product of two numbers, they are transformed to powers of ten and added. The resulting sum is the transform of the product, and the problem is completed by performing the inverse transformation, i.e., by finding its antilogarithm. Similarly, the LaPlace transform permits the use of simple algebraic operations in the solution of differential equations.

Use of the transform method of analysis is facilitated by tables of transform pairs (for obtaining the transform of a response as a function of time) and inverse transforms (for obtaining the time response from the combined system transform) which have been compiled. Several excellent texts on automatic control[3] containing such tables of commonly used functions have been published. The use of these tables further simplifies the solution of differential equations.

Determining Output

In order to complete the solution of mechanical system response through use of the simplified approach, one additional concept has to be defined. The problem of finding the output of a component for a given input arises so frequently in the analysis of control systems that it is worthwhile to develop a method of expressing this response.

The method most commonly used is to write the transfer function of the device, which is obtained from the LaPlace transform of the differential equation by assuming the system to be initially at rest and thus providing for all initial conditions to be zero. The transfer function is then a description of a component for the case of an exponential signal ϵ^{rt} being transmitted and is obtained by solving the transformed differential equation describing its energy transfer characteristics for the ratio of the output to the input.

A transfer function of a control system element is a mathematical expression that indicates the dynamic characteristics of the element in terms of the ratio of the output to the input of the element, and it expresses this ratio in terms of magnitude and units. It also expresses the dynamic characteristics of the element in terms of its parameters.

Referring again to Equation 13 it can be seen that the transfer function of the mechanical system becomes

$$\frac{\theta}{\theta_m}(s) = \frac{\frac{k}{D}}{s + \frac{k}{D}} \qquad (22)$$

Note that this equation is equivalent to Equation 21 which was obtained from the transformation of a first-order response as a function of time. Therefore, by solving for the device or system transfer function, the transformed differential equation describing the device characteristics is

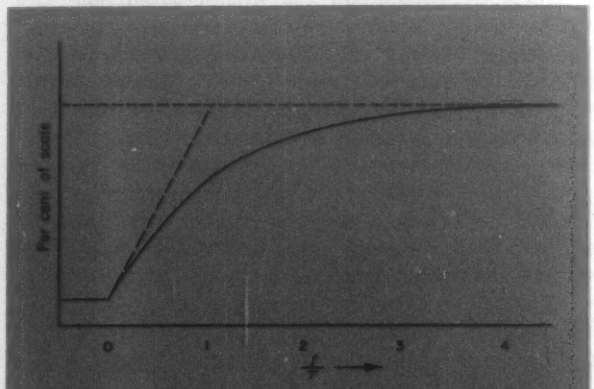


Fig. 4—Plot of output as a function of time or the response of a first-order component to a step input. The ordinate units are time divided by the time constant; the straight-line plot illustrates the definition of the time constant—the time required for the variable to increase to its final value if it continued at its initial rate

automatically obtained. Usually a block diagram, *Fig.* 6, is used to indicate the relationship expressed by the transfer function of the component.

One of the conditions which must be met in a physical system is that the properties of the system, the input, and the response, must all be measurable. The process of physical measurement is

of great importance, since it is the means and the only means by which one can actually obtain the system properties. The transfer function concept helps relate the system representation made in the analysis to an actual component of the system.

Advantages of this approach are immediately apparent. Since the parameters of the system retain their identity, it is much easier to evaluate their effect upon the complete system response. Also the characteristic equation of the response may be obtained directly, and thus the form of the transient response is immediately known.

Another important advantage afforded through use of this concept is in determining the response of a system for various types of input. Suppose it is desired to obtain the output response of the mechanical system shown in *Fig.* 5 for a step input with an amplitude, A. This input is the same as that shown in *Fig.* 3. Its transfer function or transform is the same as that shown in Equation 19. Therefore,

$$\theta_m(s) = \frac{A}{s} \quad \ldots\ldots (23)$$

Substituting this in the transfer function of Equation 22 yields

$$\theta(s) = \frac{A\frac{k}{D}}{s\left(s + \frac{k}{D}\right)} \quad \ldots\ldots (24)$$

By means of the previously mentioned inverse transform tables the expression for returning the transformed differential equation to the time domain is found to be

$$\theta(t) = \frac{A\frac{k}{D}}{\alpha}(1 - \varepsilon^{-\alpha t}) \quad \ldots\ldots (25)$$

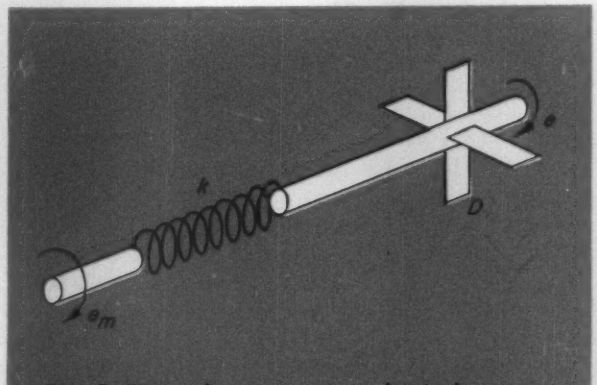


Fig. 5—First-order response mechanical system consisting of a spring connected to vanes on the output end of a shaft. It is assumed that the spring is initially unstressed and returns to an unstressed condition after the transient dies out

where $\alpha = k/D$. The transient response of the mechanical system becomes

$$\theta(t) = A\left(1 - \varepsilon^{-\frac{k}{D}t}\right) \quad \ldots\ldots (26)$$

Equation 26 has the same form as Equation 12 and it gives proof that the mechanical system has the same type of response as the pressure system.

▶ Time Constant Characteristic

The transient curve plotted in *Fig.* 4 can be said to be a plot of Equations 12 and 26 as a function of time and is representative of the response of first-order systems. An interesting property of first-order systems can be illustrated from an examination of the solutions obtained as the response of the two first-order systems which have been analyzed.

The initial slope of the response of Equations 12 and 26 can be obtained by taking the derivative of the output response and setting the results equal to zero. Using the results of the analysis of the pressure system as an example it can be shown that for

$$e_o(t) = e_{in}\left(1 - \varepsilon^{-\frac{t}{RC}}\right) \quad \ldots\ldots (12)$$

the first derivative becomes

$$\frac{de_o}{dt} = \frac{e_{in}}{RC}\varepsilon^{-\frac{t}{RC}} \quad \ldots\ldots (27)$$

At $t = 0$

$$\frac{de_o}{dt} = \frac{e_{in}}{RC} \quad \ldots\ldots (28)$$

This is the initial rate of increase of the output variable. If the output voltage had continued to increase at this rate for a time $t = RC$, it would reach the value

$$\frac{e_{in}}{RC} \times RC = e_{in} \quad \ldots\ldots (29)$$

that is, it would increase to its final value. By definition, the time RC is known as the time constant and as shown it is the time required for the variable to increase to its final value if continued at its initial rate. All linear, constant-parameter systems which are described by first-order equations have this property.

From the results of the analysis of the pressure and mechanical system it can be seen that the time constant is a characteristic of the system and is indepedent of the input to the system. In fact, the time constant is the root of the first-order system and can be determined directly from the system characteristic equation. Its reciprocal also appears as the coefficient of time in the decaying exponential of the time response equation.

The time constant, sometimes called first-order lag, is the single most important characteristic

of the first-order system. The time constant affords a convenient measure of the length of the transient response of a single capacity system. It can be shown mathematically that the time constant is equal to the time required for the variable to reach 63.2 per cent of its final value. For a time equal to two time constants the variable will reach 86.5 per cent of its final value; for three time constants 95 per cent of its final value, and for four time constants 98 per cent of its final value.

Response of a Second-Order System

While first-order systems are quite common in automatic control design, the response of higher order systems are of more than academic interest to the control engineer. This is particularly true of the response of complete control systems since the combination of several components almost always results in a higher order response.

There are several characteristics and definitions associated with second-order systems which are used quite extensively in automatic control work. These may best be illustrated by making an analysis of such a system.

A mechanical system whose response is represented by a second-order differential equation is shown in *Fig.* 7. Notice that this is the same type of system as shown in *Fig.* 5 with load inertia added. It should be pointed out here that the mechanical system shown in *Fig.* 5 is not representative of a useful system since it is difficult to find an existing device without inertia. It was used as an example to explain the mathematics in a simplified manner.

Again referring to TABLE 1 and equating torques associated with each component of the system the following differential equation is obtained

$$k\,(\theta_m - \theta) = D\frac{d\theta}{dt} + J\frac{d^2\theta}{dt^2} \qquad (30)$$

The physical meaning of the addition of load inertia to the system is important. As before, introduction of an angle of twist $\Delta\theta_m$ to the system imparts a force which causes the output to seek a new angular position θ. The damping component again offers a force which opposes this change in angular position with a net result of dissipating energy in the system. On the other hand the mass of the load tends to momentarily absorb energy in that force is required to start the mass moving. It can also be seen that the velocity of the mass increases until the output angle is equal to the new input angle, meaning that the spring is unstressed.

At this time, the angular velocity of the mass is at a maximum and the momentum of the mass carries on, stressing the spring in an opposite direction until the reversed torque of the spring

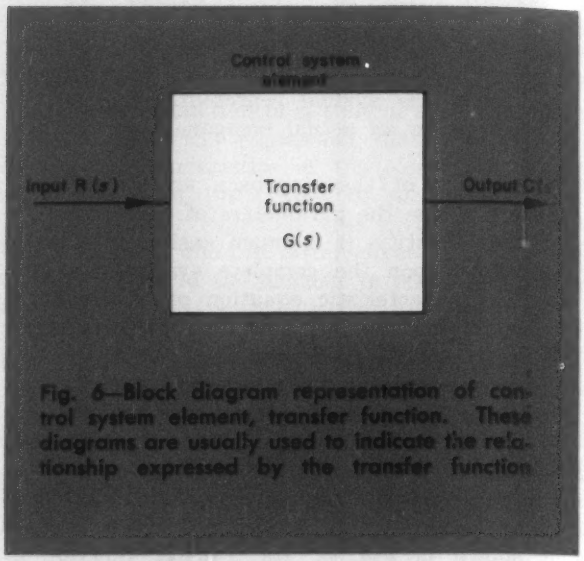


Fig. 6—Block diagram representation of control system element, transfer function. These diagrams are usually used to indicate the relationship expressed by the transfer function

decelerates the mass to a stop and reducing the inertia to zero. The spring must now twist through an angle in an opposite sense in order to again become unstressed. Were it not for the presence of damping it can be seen that the system would continue to oscillate since the damping force tends to oppose such oscillations. The amount of damping, practically speaking, controls the amount and number of such oscillations.

This physical interpretation will be shown mathematically by using the simplified method of analysis just developed. The transfer function becomes

$$\frac{\theta}{\theta_m}(s) = \frac{k}{Js^2 + Ds + k} \qquad (31)$$

Use of the transfer function automatically assumes that the form of the output response is the same as the input, Ae^{st}. Since the response is represented by a second-order equation it has two roots which may be determined by using the quadratic formula. Therefore,

$$s_1, s_2 = \frac{-D \pm \sqrt{D^2 - 4Jk}}{2J} \qquad (32)$$

are the roots of the equation. For all stable systems, that is, those whose oscillations eventually die out, the roots s_1 and s_2 may be complex with negative real parts, equal negative real, or unequal negative real, depending upon the numerical values of J, D, and k. For the condition of an oscillatory system response just described, the roots will be complex, where $4Jk > D^2$ and it can be seen that this condition depends upon the value of the damping component.

Before examining the response in detail it is convenient to introduce a few simplifications. Two parameters, namely, the natural frequency ω_n, and the damping ratio ξ, are defined so that the expression for the roots may be simplified. The quantity ω_n, the system undamped natural frequency,

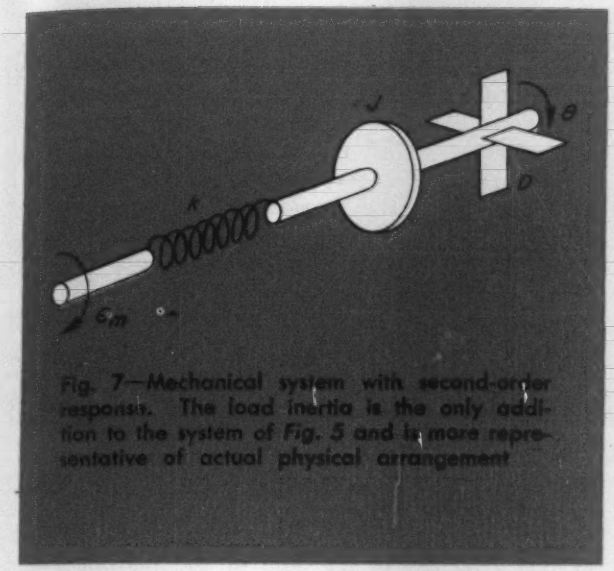


Fig. 7—Mechanical system with second-order response. The load inertia is the only addition to the system of *Fig. 5* and is more representative of actual physical arrangement

is defined as the frequency at which the system would oscillate if there were no damping. Mathematically this occurs when the component D is equal to zero. Therefore, the natural frequency is defined as

$$\omega_n = \sqrt{\frac{k}{J}} \qquad (33)$$

The damping ratio is defined as the ratio of the actual system damping to that required for the system to be critically damped, i.e., the response of the output angle approaches its final value but never exceeds it. Mathematically this is equal to

$$\varepsilon = \frac{D}{D_c} \qquad (34)$$

Critical damping occurs when the two roots shown in Equation 32 are equal. This means that the portion of the equation

$$\sqrt{D^2 - 4\,Jk} = 0 \qquad (35)$$

Since, by definition, this is the condition for the system to be critically damped, D becomes D_c and is equal to

$$D_c = 2\sqrt{Jk} \qquad (36)$$

the damping ratio then becomes

$$\xi = \frac{D}{2\sqrt{Jk}} \qquad (37)$$

Using these definitions the transfer function can now be rewritten as

$$\frac{\theta}{\theta_m}(s) = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2} \qquad (38)$$

Again using the inverse transform tables and for step input of amplitude A the response of the output angle as a function of time would be

$$\theta(t) = A\,[1 - \beta\,\varepsilon^{-\xi\omega_n t}\sin(\omega_r t - \psi)] \qquad (39)$$

where ψ, β, and ω_r are functions of ξ and ω_n.

This equation shows that the response of an oscillatory system takes the form of a sine wave, in fact, the transient described by Equation 39 is known as a damped sine wave response because of the product of the decaying exponential and the sine wave. The question naturally arises as to why a response in the form of a sine wave was obtained when, as per the definition of a transfer function, a response of the form $A\epsilon^{st}$ was assumed. The answer lies in the basic definition of a sine function. Mathematically it can be shown that a response of the form $A\epsilon^{st}$ with roots equal to a pair of conjugate complex numbers can be represented by a sine function. Such a definition is basic and

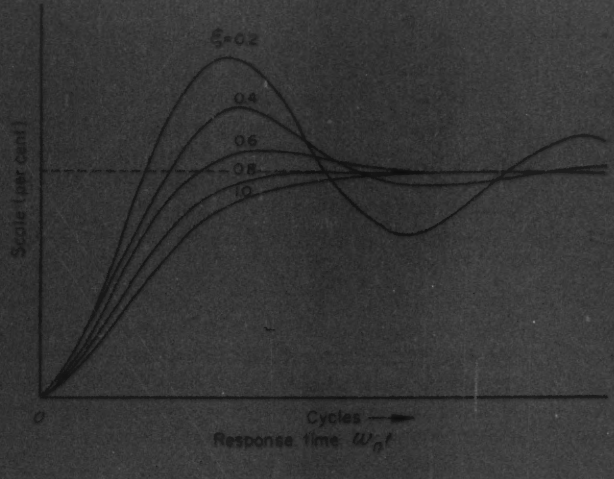


Fig. 8—Transient curves have been plotted with the time scale as a function of response time and it can be seen that for larger natural frequencies, the actual response time for the system becomes smaller. As a general rule, a control system is required to reach its steady-state condition in a minimum time after a disturbance with special limitations for specific applications

is used quite extensively in the study of the transient behavior of physical systems.

The response of a second-order system as represented by Equation 39 has been plotted in *Fig.* 8 for various damping ratios. Notice that for smaller damping ratios (less damping) the amount of overshoot of the variable above the final value grows larger. The amount of overshoot acceptable in the response depends upon the particular application of the control system. Present day engineering practice establishes a range of damping ratios of from 0.4 to 1.0 and is a good starting point in adjusting the transient response of a system. The accepted criterion of one-quarter amplitude recovery for industrial process control systems calls for a damping ratio of approximately 0.5.

▶ Response of Higher Order Systems

In the previous discussions responses of three basic types of differential equations have been presented. They were the step function or impulse, the first order differential equation, and the second-order differential equation. Their transfer functions were found to be

1. Step-function or impulse

$$KG = \frac{1}{s}$$

2. First order

$$KG = \frac{1}{\tau s + 1}$$

3. Second order

$$KG = \frac{1}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

where KG is the common notation for transfer function and τ is the time constant of the first-order system. It has been shown that the denominator of the transfer function is the characteristic of the differential equation describing the system response and that the roots of the characteristic equation determine the time solution of the response. Also, it has been determined that introduction of a disturbance of the form Ae^{rt} through use of the transform method yields an output of the same form. It follows then that a higher order characteristic equation can be factored into a combination of one or more of the above forms of transfer function. For instance, the equation

$$s^4 + as^3 + bs^2 + cs = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (40)$$

can be factored into

$$s(\tau s + 1)(s^2 + 2\xi\omega_n s + \omega_n^2) = 0 \quad \ldots\ldots\ldots (41)$$

By the principle of linear superposition, the system response is the sum of the responses attributed to the specific roots of the characteristic equation. This feature of the transfer function concept made possible by the use of the LaPlace transform method is of great utility to the control engineer. In the study of complete control systems he need only determine the transfer function of each component of the system and combine them according to the configuration of the system. Each component retains its identity throughout the analysis and its effect upon the system response can be readily evaluated. This systematic approach to control system design will be the topic of discussion in the next article of this series.

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PLAN FOR LEISURE

AS WE LOCK AHEAD to the production miracles automation seems to promise, one thing seems reasonably clear—we're all going to have a higher standard of living and more leisure time. While no one in his right mind is likely to quarrel with the ultimate desirability of this, it does raise a fundamental problem—what are we going to do with this leisure time? Indeed, this would seem like a pleasant problem to cope with.

Few would object to earlier retirement with more years to enjoy a well deserved leisure. Unfortunately, it doesn't work that way. Retirement is too often a time of blasted hopes and disillusionment. The fact is that we actually know very little about retirement. It has never been much of a problem until now. However, with the recent lengthening of the life span and the added industrial implications of automation, it's high time that some fundamental work is done on retirement.

A national organization (not run by the government, but by business and industry) should be set up to study and co-ordinate helpful programs for retired persons. Certainly, business and industry should take the lead in offering its executives and workers who retire something better to do than mounting butterflies and collecting matchboxes.—*Ruel W. Elton, American Trade Association Executives.*

Fig. 1—Los Angeles sales office, one of the many where order tapes are prepared on Flexowriters as a product of the original order entry and transmitted on Teletypewriters

INTEGRATED DATA PROCESSING

COMES TO LIFE

Automation of service to customers brings added dividends to management in the availability of timely business data. Here the common language vehicle demonstrates the reality of promises suggested by automated paperwork with a *live* case example

CUSTOMER ORDERS are the life blood of industry and certainly should be given maximum attention regarding prompt action, efficiency and accuracy. Integrated data processing provides a means for optimum customer service in addition to increased internal operating benefits.

Orders are so handled by the Aluminum Co. of America that they pass through central production planning functions in Pittsburgh and are in the designated plant ready for manufacture to begin with in less than a 24-hour period from entry in a local sales office. This is a considerable accomplishment in view of the fact that there are 60-Alcoa sales offices from coast to coast, and 24-different plants throughout the country. As many as 1000 orders might be handled through this network in a single day.

This service is made possible because of a high degree of mechanization in the recording and transmittal of orders. In fact, following the initial writing of a sales order at the point of origin, an operation which is itself partially automatic, all or any selected portion of the information may be reproduced mechanically on needed papers for a number of purposes.

Finally, each plant is in position to supply shipment manifest to the customer, any necessary inspection reports with the shipment, and to mail the invoice immediately after the loading of a shipment is completed.

To realize its communication needs, the company expanded its private line Teletype network, furnished by the Bell System, from a total of 9000 miles to over 20,000 miles. In Pittsburgh, one of

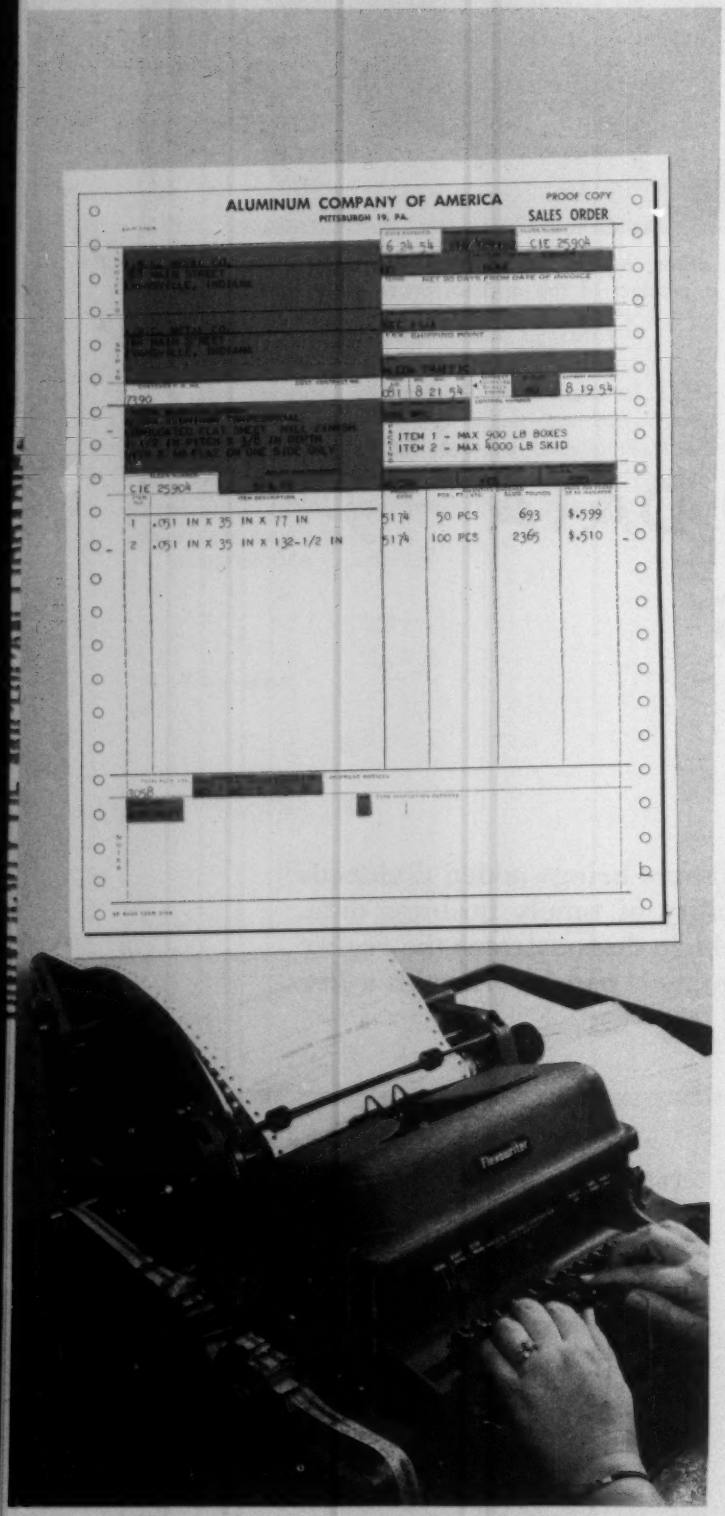

ALUMINUM COMPANY OF AMERICA
PITTSBURGH 19, PA.
PROOF COPY
SALES ORDER
ITEM 1 - MAX 900 LB BOXES
ITEM 2 - MAX 4000 LB SKID
1 .051 IN X 35 IN X 77 IN 5174 50 PCS 693 $.599
2 .051 IN X 35 IN X 132-1/2 IN 5174 100 PCS 2365 $.510

Fig. 2—In the sales office, as the typist originates the proof copy, the sales order is punched into a five-channel tape as the medium for automated paperwork. Items in the colored area of the form are entered mechanically from a master customer tape

the largest relay centers of its particular kind in the world forms the hub of the system. Coupled with this facility is the use of five-channel tape as a common medium to operate and integrate electric typewriting, tabulating-card punching, teletypewriting and potentially, other equipment in the mechanical processing of order data—reducing clerical lag in the order-production-delivery cycle.

Alcoa exhaustively proved, selected, and applied at the several stages of the order-to-invoice cycle, modern methods and equipment which were most practical in the light of circumstances to produce working papers without copying data by hand. This, plus the simplification achieved by Standard Register Co. in the design of forms—handled automatically in record-writing machines—have enabled Alcoa to realize a distinct service to customers in and through paperwork efficiency.

Customers can be assured that an order completes the circuit from the sales office to the network at Pittsburgh to the plant, on the same day it is transmitted from the sales office. They can also be told that by shortly after noon each day, the sales office will have a list of all shipments made the previous day against orders.

Obviously, in serving customers by handling orders with much greater speed than was previously possible, the company is helping itself, too. The procedure yields data on the current day's orders placed; their effect on raw material requirements, inventories, plant work loads, shipment schedules, etc., can be seen without delay through the medium of punched card accounting analyses and reports. Each morning the Pittsburgh Office receives a report of the previous day's shipments from every plant.

The new system has entailed a considerable investment in equipment for sales offices, plants and home office, plus the leased wire facilities already mentioned. Alcoa undertook it—and the infinitely detailed work of completely revising procedures—with the same motive as that governing its current expansion of production facilities or its expenditures for research and development: Better ability to serve customers in an expanding but highly competitive market. Shortening the period between receipt of a purchase order and the time a plant can start work on the order—to say nothing of the accuracy of production and shipping papers that avoids delays all along the line—puts the company that much closer to customer needs and market demand.

Point of Origin

The notable feature of the order-processing system is the mechanical, automatic transcription or duplication of constant data, to produce various needed documents speedily and accurately. The guiding principle in its development was that basic information should be initially written down in a form that thereafter makes manual copying and checking unnecessary.

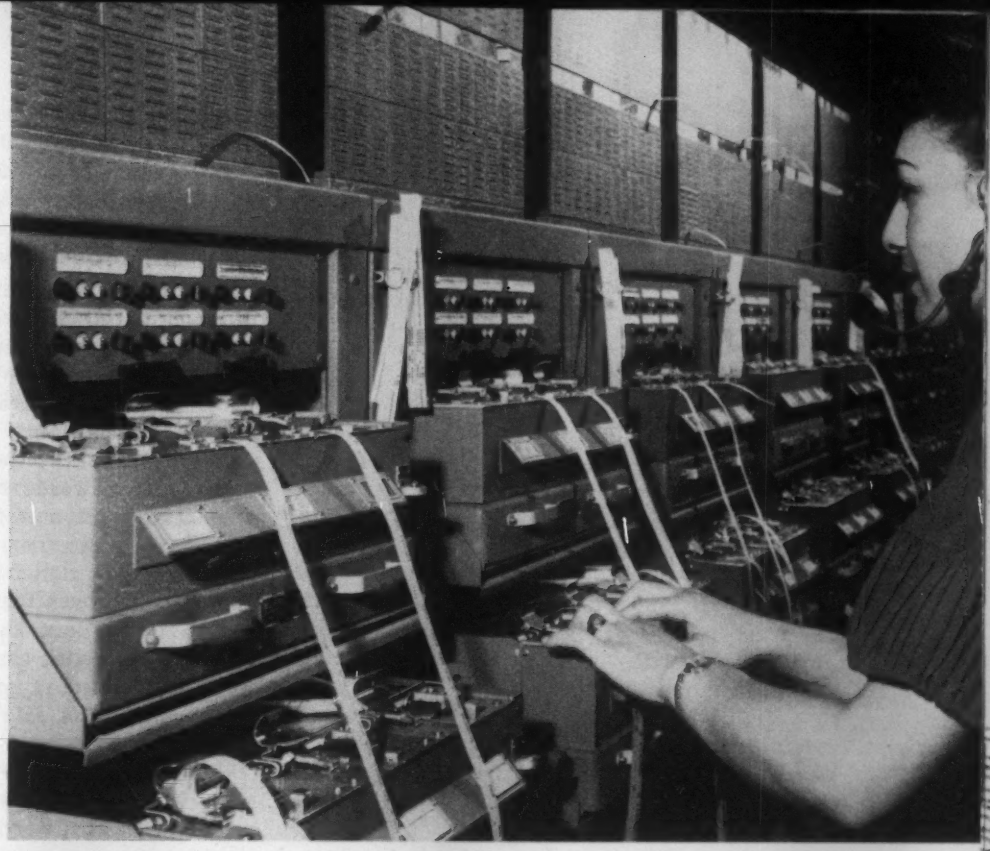


Fig. 3—Order is received in the relay center at Alcoa headquarters in Pittsburgh. This center serves as the control point for the company's Teletype communication network

In large measure, as will be seen, this system is a demonstration of how data is recorded at the point of origin in the mechanical form of a five-channel tape; and of how that tape serves to link electric typewriters, teletypewriters and tabulating equipment in expressing the data on paper where needed.

Sales office paperwork is the starting point of the system's accuracy and efficiency. Sales offices covering the country are equipped with Flexowriters, electric typewriters produced by Commercial Controls Corp., which are capable of reading five-channel tape and of producing such tape as a by-product of typing, *Fig.* 1. Sales offices are equipped also with Teletype machines and are connected by wire to the production planning division in Pittsburgh either direct or, for west coast offices, via a sub-relay center at Vernon, Calif. Alcoa plants throughout the country are also directly connected to Pittsburgh by leased wire in the Teletype network.

The sales office is prepared to speed its original writing of the sales order, through mechanization, because a good part of the data is already filed in coded tape form along with a customer card bearing the typed record name and address, shipping instructions, billing requirements and various other data that are constant from order to order placed by regular customers.

A sales order abstract is written to translate only such data from the customer's purchase order as pertains to this order alone and is not constant, and to put these items in position on a form matching that of the sales order. This first and highly important action on the order is obviously simplified by the fact that all constant data is already prepared to be typed mechanically.

Customer's order, sales order abstract, customer card and tape are given to the operator of the Flexowriter, *Fig.* 2. It is her function to prepare a complete proof copy sales order as the machine simultaneously punches a new tape in which the entire order is coded. This step is in preparation for tape transmission of this and other orders to Pittsburgh. Having inserted the permanent customer tape in the reader of the Flexowriter, and referring to customer card and the abstract, the operator completes the proof copy by a combination of automatic typing and manual insertion of the necessary variable items.

If a typing error occurs, it is caught at the instant or upon checking the completed proof copy sales order against the customer order, and is easily corrected upon the paper copy and in the tape before transmission and perpetuation of the error. Approved proof copy and tape go to the Teletypewriter.

Here, in the minimum of time, the customer's order has been translated into a sales order, acknowledged in the form which will thereafter be followed in all communication of that order data, and transmitted for acceptance in Pittsburgh. Collateral copies have been automatically produced in the process. When an order has been wired to

Pittsburgh the transmission tape is destroyed the following day.

Home Office Action

At Pittsburgh the order is received on perforated tape in a relay center, *Fig.* 3 which controls the entire Teletype network. All orders as well as messages, change orders and shipment reports come to this center for distribution to ultimate destinations. Its equipment includes reperforators for incoming traffic, transmitters for outgoing traffic, control positions for dialing stations and servicing outlying stations, and TWX machines—12 points in the system being covered by Teletype exchange service. All traffic through this center is handled on tapes and no page copy is received except on the TWX equipment or on a monitor. Directly connected to the relay center is the Teletype room of the production planning division, *Fig.* 4. Equipment consists of page receiving Teletypewriters, reperforators and transmitters.

A Teletypewriter produces a tape and a four-part set of the sales order consisting of the production planning division copy, tabulating copy, Teletype copy and a plain paper receipt copy. Upon receipt, a serial number is assigned to the tape and stamped on both it and the typed copies of the form. Tape is coiled and placed in a pigeonhole file by number. Receipt copy is temporarily filed in the Teletype room, by sales office, for a quick count of the number of orders transmitted by an office and a check against the number that office reports at the end of transmission—an extra safeguard against loss or duplication of an order.

Assuming this order is received without an indication of the plant of allotment, the other copies are delivered to the product planner concerned. It is his responsibility to allot the order promptly and he pencils a standard abbreviation for the plant location in the *Ship From* block. He separates the form, retains the production planning division copy, and forwards the other two copies to the tabulating section of this division and to the Teletypewriter room, respectively.

It should be noted here that the tabulating section gets the data for punching cards on incoming orders throughout the day as soon as they are allotted to plants; that the timeliness of the various analyses and reports which tabulating prepares is an important side advantage of the speed in order processing.

In the Teletype room the returned Teletype copy is used to prepare a line-up for transmission of this and other orders to the proper plant, and to identify the tape by pigeonhole number. On orders directly allotted by the sales office, this copy remains in the room, and the distribution of other copies is the same as for an order allotted by the production planning division.

Transmission to the plants takes place in the late afternoon and evening, as the plants notify the relay center that they are prepared to receive orders with the proper sets of forms in their teletypewriters.

Tape is used to transmit the order, while the

Fig. 4—Tapes of orders received are temporarily filed in Teletype room of the production planning division. Transmission to plants takes place during the later part of the day. Sending Teletypewriters produce sales order copies required in the Pittsburgh office

Teletype copy serves in verifying correct transmission. The *Ship From* point is added in transmission by means of a separate and permanently filed piece of tape, preceding the order tape, which contains the complete name and location of the plant to which production planning has allotted the order. In transmitting the order via relay center to a plant, the Teletypewriter in the production planning division simultaneously prepares the copies of the sales order required in the Pittsburgh office, contained in a five-part continuous set.

Prior to being filed, the last copy of this set, the production planning division index, serves to account for the total number of orders transmitted to each plant. Each morning, the plant advises the production planning division of the number received the previous day and thus a check is had against the loss of any order in transmission.

Factory Data Processing

At the plant of allotment, the receiving Teletypewriter writes the sales order on a four-part form, from the tape on which the order is received. In so doing it creates, as the original, a black spirit duplicating plant master (Copy 1 printed on master stock and backed by black hectograph carbon). Part 2 is a transmission proof and allotment notice copy, which is immediately mailed to the district sales office, for comparison with its file copy of order and, in the case of a previously unallotted order, to show which plant will produce and ship it. Part 3 is another transmission proof and allotment notice for the branch sales office, if such an office is indicated in the order number. The plant file copy is a permanent record of the complete order.

The foregoing shows how an order placed with a sales office completes the circuit from the sales office to the network center and then to the plant on the same day it is transmitted from the sales office. An order is in the plant, ready for preparation of the necessary production papers by the time, or before the customer receives the acknowledgment from his sales office.

In broad terms of the system as a whole, the plant documents shipment of the order by means of specified, standardized forms of package identification tags or tickets; shipment papers and an invoice. In the interim, of course, there is internal paperwork necessary for producing the order.

Upon receiving the teletypewritten sales order the first step at a plant is to reproduce several information copies of the complete document, as needed for the mill office and planners, by the black spirit duplicating process employing the plant master. These copies are on preprinted take-off sheets, titled "copy sales order".

On a large number of sales orders the desired shipping schedule is entered by the sales office in a *Shipment Estimated by Week Ending* block. For those orders for which the shipping schedule is not established by the sales office, the plant will produce copies of a shipping estimate on another form, using the sales order plant master, but blocking out sections including the price column which is used for the insertion of estimated shipping date opposite item description. Copies of the shipping estimate go to the sales office, thence to the customer, and to the production planning division.

Fig. 5—Load-tally copy of manifest serves as a loading check sheet and when completed contains information to complete the master for reproducing needed invoice copies

For planning, production, dispatching, timekeeping and other functions in the plant, each single item of a sales order needs to be expressed on various forms. With the black spirit plant master, it is easily possible through the use of blockouts, to imprint such forms with the desired data, the single item number and description, and any accompanying notes—whether the sales order includes one item or more. Such preprinted forms provide spaces for required information to be added at the time of order analysis and scheduling.

As a by-product of the order-entering system, the tape produced on the receiving Teletypewriter will be available for the mechanical preparation of certain papers as future developments might indicate.

In different plants, filling orders for Alcoa products as varied as sheet and plate, extruded shapes, wire, rod and bar, castings, electrical conductors, forgings, drawn tubes, foil and milk bottle caps—differing in size, layout, processes and handling

equipment—there is naturally a considerable variation in procedures for the internal paperwork mentioned. Beyond the preparation of sales order copies and other papers discussed, no purpose would be served by selecting and describing any one production system. It is also true, however, that coincident with development of the procedure, special procedure committees in every plant were at work not only to accommodate their paperwork to its specifications, but also to develop better methods in the production control areas as a whole.

▶ Packaging and Shipping

Preprinted forms for package identification used at all plants are uniform in arrangement with a section of the sales order to provide these pertinent items of constant data: *Ship To, Customer P.O.No., Govt. Contract No., products as follows, Alcoa No., Alloy and Temper, Item No. and Item Description.*

Tags or tickets as needed for shipment of the order are prepared in a number of ways, to provide one or two for each package. For any given shipment, there may be anywhere from one to several hundred sets of tags all alike except for the preprinted package numbers and the quantity. In such cases, some plants employ a Flexowriter to produce the tags or tickets automatically on marginally punched continuous forms. In other plants they may be duplicated from the plant master sales order. Another method is to type a lithographic duplicating mat for reproduction of tags or tickets by this process. When only a few tags are needed they may be manually typed. As material is packed, quantities are entered on the identification forms for each package; the labels or tags are applied; and copies or stubs are held by customer and order number pending shipment.

When the order has been packed for shipment, these copies or stubs, constituting reports of material packed, are sorted into order item and package number sequence and the weights and quantities of the order items are totaled. Price extensions are made, and transportation allowances and similar new information are noted.

At this point, and for the first time, a new form is created. This is not at variance with the principle of integrated data processing for this is the initial recording of much of the data here written; and it is recorded in a form to permit mechanical production of other papers required. From a summary of material to be shipped and a copy of the sales order, a typist operating an electric typewriter writes a four-part invoice master and shipment manifest. The bottom 3-inch section of this form is designed for a listing of as many as 14 packages in the shipment by item number; package number; package type and size; pieces or feet, etc. of the product; net pounds and gross weight.

That listing is retained on the three manifest copies only and is removed by detaching a stub from the No. 1, black spirit duplicator invoice master copy. Beside the invoice master, the other three parts of the form are load tally and file copy, extra copy, and customer copy of the shipment manifest. Prices and extensions appearing on the master are eliminated from the latter copies by special treatment of the interleaved carbons. Inspection reports, when required, are reproduced

Fig. 6—Five-channel tape being prepared from tabulating cards by an IBM machine in a plant office. Cards were previously punched for each item shipped from the plant

from the invoice master. The manifest copies, together with bill of lading and inspection reports, when required, are delivered to the loading area.

The load-tally copy serves as a loading check sheet, *Fig.* 5, and a truck receipt when shipment is a pickup by customer truck or by contract carrier. After shipment is loaded, the load tally copy is returned to the office where shipment date and any other necessary information not previously available are added to the invoice master. Customer copy of shipment manifest accompanies the shipment in a special waterproof envelope which also contains inspection reports, if any. The extra copy of the manifest is available for the customer in case it has been requested—with shipment, or with invoice or separately addressed to an individual.

Now the plant prepares required copies of the invoice, and a shipment notice if requested by customer, by the black spirit duplicator process from the invoice master. The basic set of take-off sheets consists of precollated preprinted copies of various colors which are distributed as indicated by their titles. While the invoice form is not identical with that of the sales order, the two are harmonious so that information on the invoice form is given in the same wording and position as on the sales order acknowledgment and package ticket, as well as on the shipment manifest and other papers produced from the invoice master. Another feature of the invoice is that it shows the status of shipment for each item invoiced as an aid in determining the status of an order.

▶ Company Wide Availability of Data

For the purpose of providing sales offices and different divisions of the Pittsburgh Office with prompt, concise information on shipments, every morning each plant prepares tapes and, through this medium, teletypes two lists of shipments for the previous day, a daily shipment list to the sales offices concerned and a daily report of shipments to Pittsburgh.

In larger volume plants having tabulating equipment, a card is punched for each order item shipped. Then by mechanical sorting and the use of card-to-tape machine, five-channel tapes for the two listings are made, *Fig.* 6.

A daily shipment list is sent to each district or branch sales office to whose customers the plant has made shipments, so that it is received early in the day following shipment. The purpose is to provide better customer service while reducing to a minimum the need for telegraph and telephone communication regarding shipments. It lists shipments alphabetically in customer-name sequence and shows *Alcoa order number, customer name abbreviation, item number, quantity shipped, pounds shipped and the routing.*

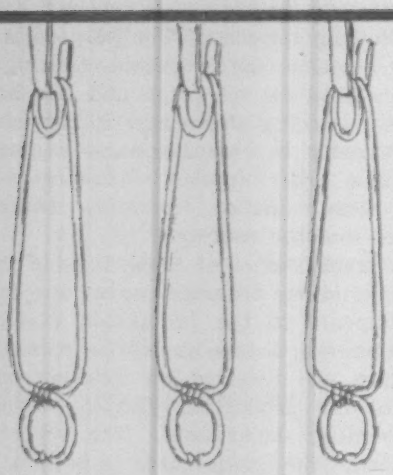
As soon as transmission of these lists is completed, the plant starts transmission of the daily report of shipments to the production planning division in Pittsburgh. A tape and three copies of a continuous form are received on Teletypewriter for the use of the production planning division and the accounting department. The report is designed to permit tabulating cards to be punched mechanically from the tape in which the report is received.

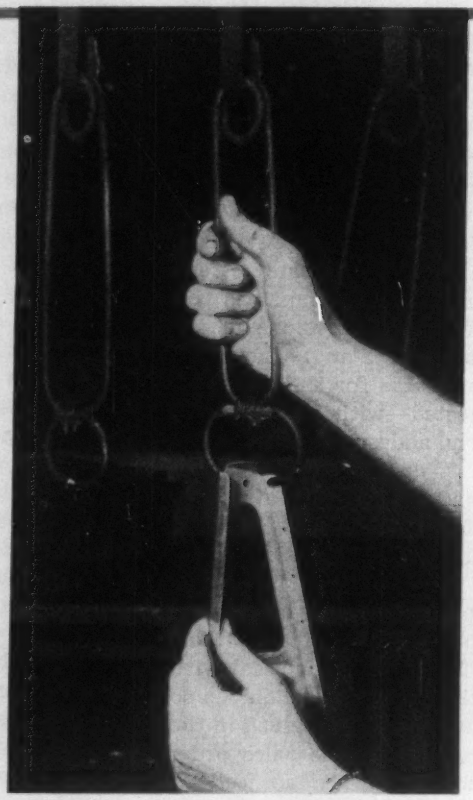
A separate report is teletypewritten by the plant for each major product—aluminum ingot or extrusions or cable and cable accessories, for example. The written form shows each item of that product shipped the previous day, identified by sales office, Alcoa order number, product number, customer name, product code, order item number and accounting code; it reports the scheduled date of shipment (from sales order), whether the shipment was complete or partial, the quantity shipped and pounds shipped.

With this comprehensive information on shipments from every plant being automatically and almost immediately punched into cards for machine accounting purposes—and with comparable records of orders entered, as earlier noted—it is clear that the company is in possession of means for a statistical picture of its business which is only hours removed from the events. From the sales order, for example, each product manager in the sales department can be provided with a statistical survey of his product showing the bookings by shipping schedule and product class. Data provided to the sales offices in the form of a weekly shipping estimate list enables them to establish the shipping schedule on sales orders, previously mentioned, or on quotations. Punched card accounting analyses of unshipped balances by schedule, product and type of transaction, are drawn from the daily report of shipments. These give only a suggestion of many such reports that are influenced by the speed and accuracy with which orders are processed through this system of mechanized paperwork.

COMPUTING AND CONTROL

Evaluation of the prospects of automation should consist of general investigations as well as the specific study of a particular selected process for automation. The general investigation should consist primarily of considering benefits of automatic installations already in operation. Invariably benefits have been beyond expectation. Secondarily a look into the parallel field of electronic computing would be helpful. Electronic computing by machines has resulted in widespread benefits in accounting functions, sales analysis, billing, etc. Many of the benefits obtained through the use of large scale electronic computing systems can also be realized through the use of automatic control systems. Also many of the same equipment principles apply to automatic control as to electronic computing.—*A. R. Rumbles, executive vice president, Remington Rand Inc.*





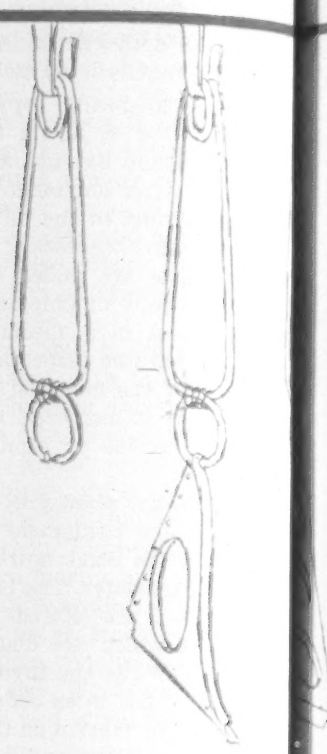


Fig. 1—In the Douglas continuous paint line, parts are manually attached to continuous conveyor by means of special spring loops which are designed to hang from hooks on the conveyor chain

Fig. 2—Conveyor line enters underground tunnel for part preparation and painting. Part size determines spacing between successive pieces to be processed

CONTINUOUS

ECONOMIC SUCCESS of any phase of continuous processing involving a multiplicity of discrete units depends largely on the flexibility of application of the equipment used. Optimum flexibility, in turn, depends on many things including the design of equipment, process specifications and proper balance of manual and machine operations. Reflection will indicate that some manufacturing operations are particularly suited to obtaining the requisite flexibility for a successful continuous processing line.

Consider the problem of painting a large variety of sizes and shapes (one inch to 6 feet in length; angles and brackets, etc.) of air-frame sheet metal parts which has been solved neatly by Douglas Aircraft Co. Standard preparation and painting specifications immediately suggested a continuous conveyor line. System has been designed which consists of an overhead rail which supports trolley brackets joined by an electrically driven chain. Hooks are suspended from the chain at 4-inch intervals. The continuous 2100-foot long conveyor

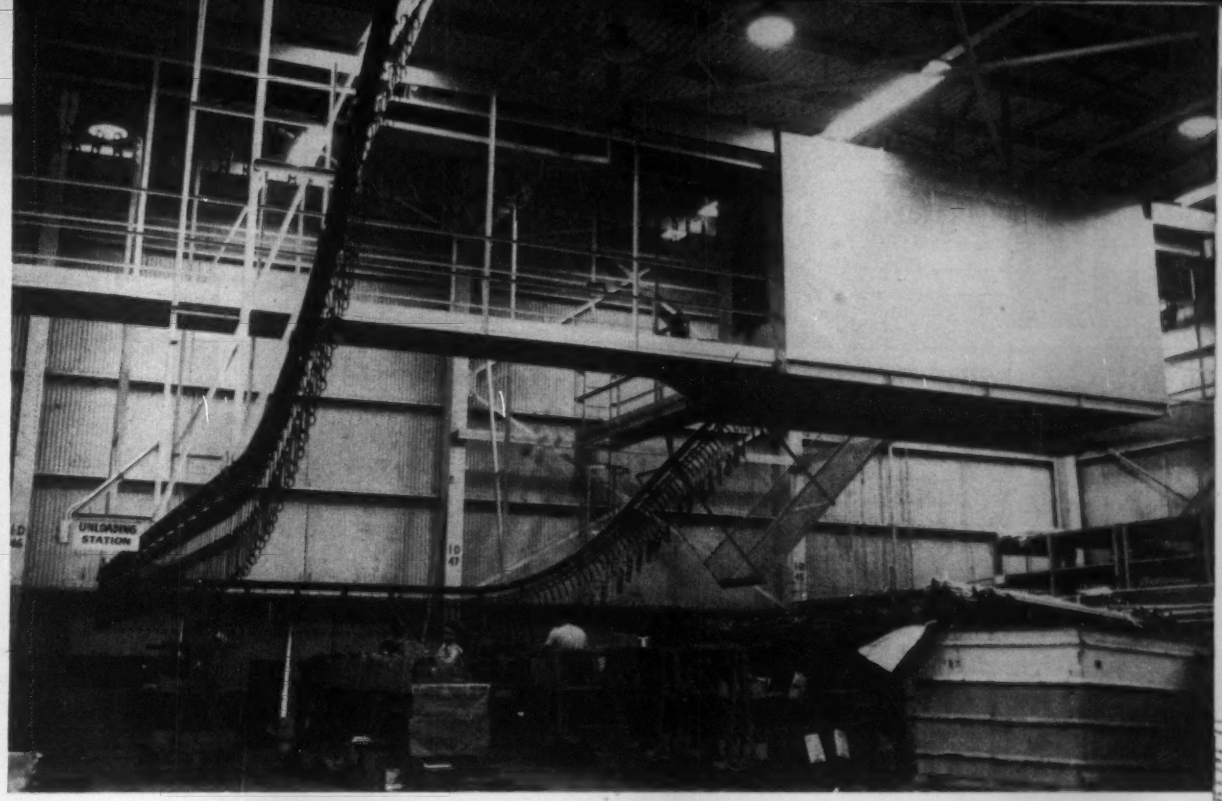


Fig. 3—Parts pass through overhead drying oven and are then directed to a manual unload point for inspection and collection for distribution

PAINT LINE
FOR DIVERSIFIED PRODUCTION

dips into five different production locations to receive, without pausing, loadings of newly formed parts which are manually attached to the hooks by a special spring type loop, *Fig.* 1.

Part preparation and painting takes place in an underground 375-foot long tunnel divided into processing chambers, *Fig.* 2. In the tunnel, the parts are successively sprayed with alkaline cleaner, rinsed with hot and cold water, Alodized, rinsed, treated with hot chromic acid, dried, cooled by air blast and painted with a zinc chromate primer. Final drying occurs in an overhead oven, *Fig.* 3, after which parts are conveyed to a manual unloading point where they are inspected and collected for distribution to stock or to the assembly line. Before the chain completes a cycle and returns to the first loading station, the line is directed through an overhead stripping chamber where the hooks are cleaned.

Improved quality of painting results from the flow coating principle of application. Paint is pumped at low pressure from a sump and slushed over parts with a fan-like action from banks of nozzles on the side and bottom of the processing chamber. Necessary agitation of the paint is supplied by the pumping from sump to nozzles.

Concern for safety of the people, plant and parts is reflected in the design of the system. Where conveyor is overhead, wire mesh has been placed below the line of travel to protect personnel from falling objects. In the event of a fire, the system automatically stops, all fans and blowers halt, paint flow turns off, heat sources are killed and carbon dioxide is discharged into sumps and closed drains. During normal operation, if for some reason the line stops, heat in the ovens is automatically shut off because of the proximity of drying temperatures to the annealing limit of the workpieces.

At speeds of 10 to 30 feet per minute, the system can deliver up to 6400 finished parts per hour. Thus, partial automation has been successfully applied to one particular difficult operation in order to realize some of the benefits of continuous line processing.

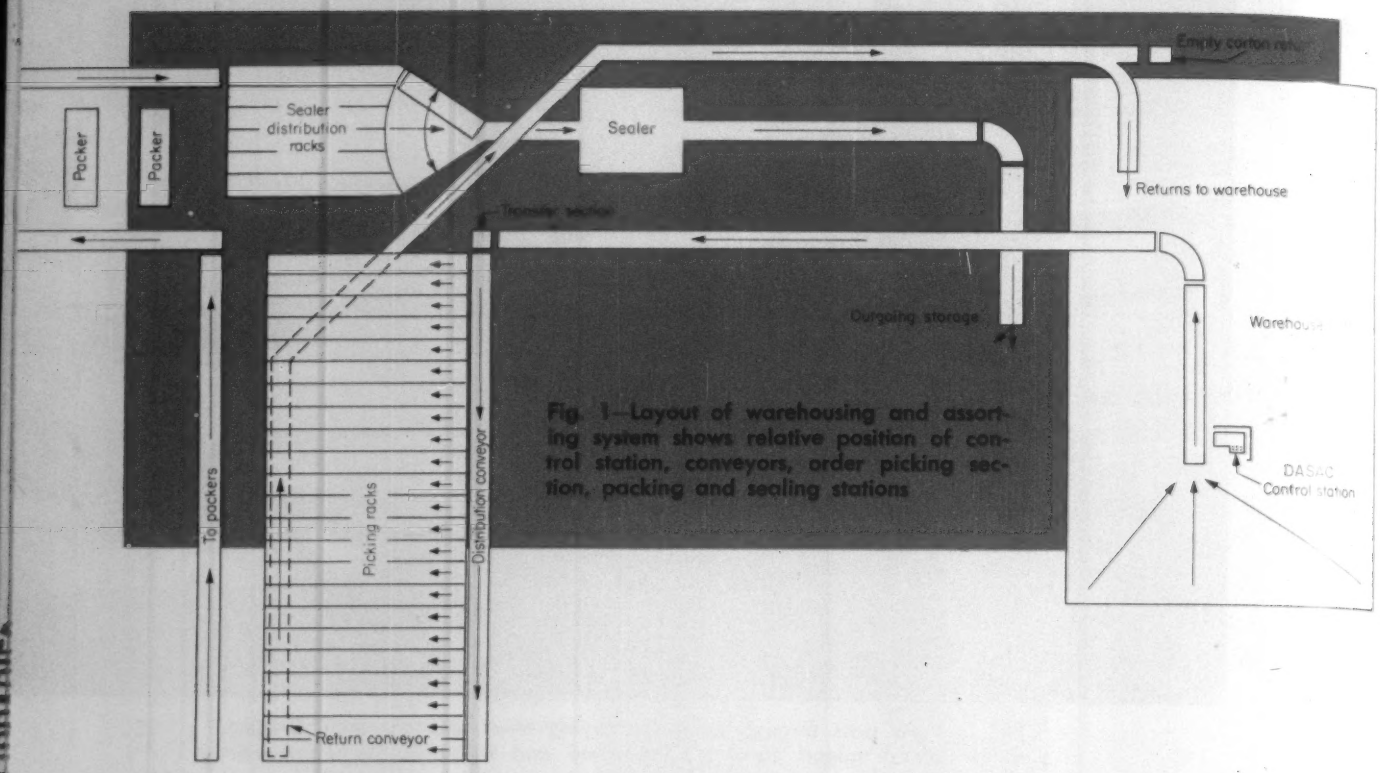


Fig. 1—Layout of warehousing and assorting system shows relative position of control station, conveyors, order picking section, packing and sealing stations

WAREHOUSING AND ASSORTING SYSTEM

Pushbutton control center with memory device is the heart of conveyor setup that simplifies order picking operation and saves space in the bargain

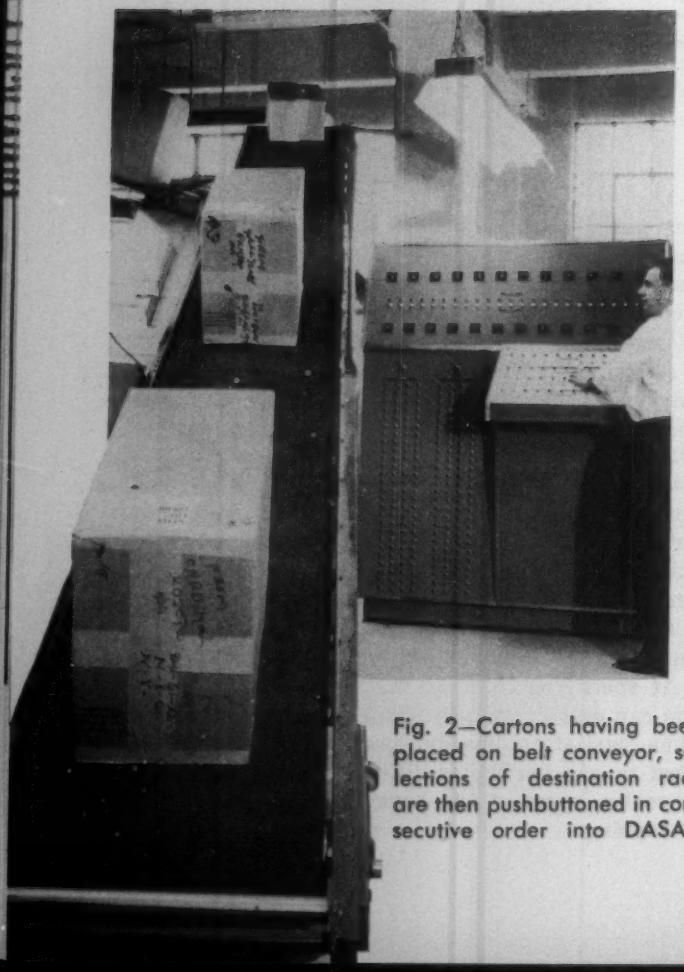


Fig. 2—Cartons having been placed on belt conveyor, selections of destination rack are then pushbuttoned in consecutive order into DASAC

AUTOMATION has an economic rationale and must produce savings—whether in reduced labor costs, waste reduction, reduction of cycle time per unit of production, reduction of space requirements per unit of production or other corollary benefits. So much has been written about the high cost of developing automated equipment, the need for product redesign, the revamping of production processes, that manufacturers and processors, may feel that automation is a "gilded lily" out of their reach.

But automation can be both practical and feasible on a limited basis. It is not required or necessary that a total production process be involved.

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Consulting Engineers, Dasol Corp.
New York

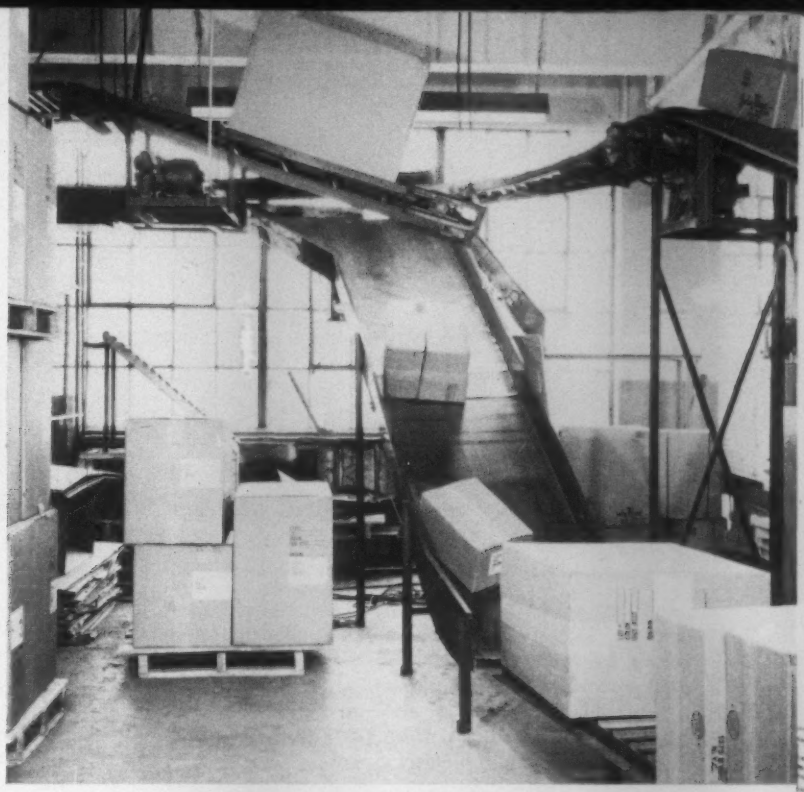

Fig. 3—Combinations of belt-booster and gravity conveyors transport containers (in upper section) over to transfer station. Lower foreground shows cartons being returned to warehouse by return conveyors

Some one part of a production process may lend itself readily to automation. This is particularly true where the process involves a great deal of materials handling.

▶ Order Picking Problem

The application shown here, *Fig.* 1, is a case in point. It was developed for Judy Bond, Inc., world's largest manufacturer of ladies' blouses, to speed up the order picking operation and reduce confusion, losses and unnecessary labor costs. Order picking consists of four operations:

1. Moving goods to the order pickers from a storage area.
2. Assorting the goods by color breakdown ready for picking.
3. Picking orders.
4. Moving the picked goods to the packers for shipment to customers.

The first two operations were selected for application of automation. It then was possible to add mechanical features to the last two operations and wind up with an automated and mechanized unit. The following results have been obtained: a reduction in man-hours per unit of production by 66 per cent, a reduction in floor space required by 65 per cent, an increase in production of over 200 per cent, elimination of all overtime, increase of shipping department capacity by 100 per cent. At the present rate of savings, the cost of the equipment will be recaptured in less than two years.

▶ Handling Floor Space

Prior to the development of this equipment, all assorting and order picking was done on large tables. The goods to be "worked off" or picked were brought to the tables in bulk containers. The assorting operation consisted of opening the containers, removing the contents to the picking tables and separating the goods by color sequence. Total space used was approximately 2600 square feet. However, only 960 square feet was actual table space. The balance was for aisles and for chain operation so that assorters and pickers could work separately without interfering with each other. As a practical matter, interference could not be avoided since these operators had to use the same aisle. Even though the aisles were large they quickly became overcrowded since they were used as temporary storage by the assorters while removing the contents to the tables for assorting.

Automation of the assorting operation became possible through the development of DASAC, an automatic selective dispatching control unit containing an electromagnetic "memory." The consulting job on this complete installation was done by Dasol Corp. whose work included the design, engineering and building of the DASAC unit. The use of this unit enables one materials handler in the warehouse to dispatch bulk containers of goods to any predetermined order rack. In place of tables, a bank of gravity conveyor racks are positioned side by side forming an immense "table" 22 feet long by 53 feet wide. Bulk containers from the warehouse are discharged at any required rack. Upon discharge, the containers roll down the rack to a stop. Space is provided on each rack to hold

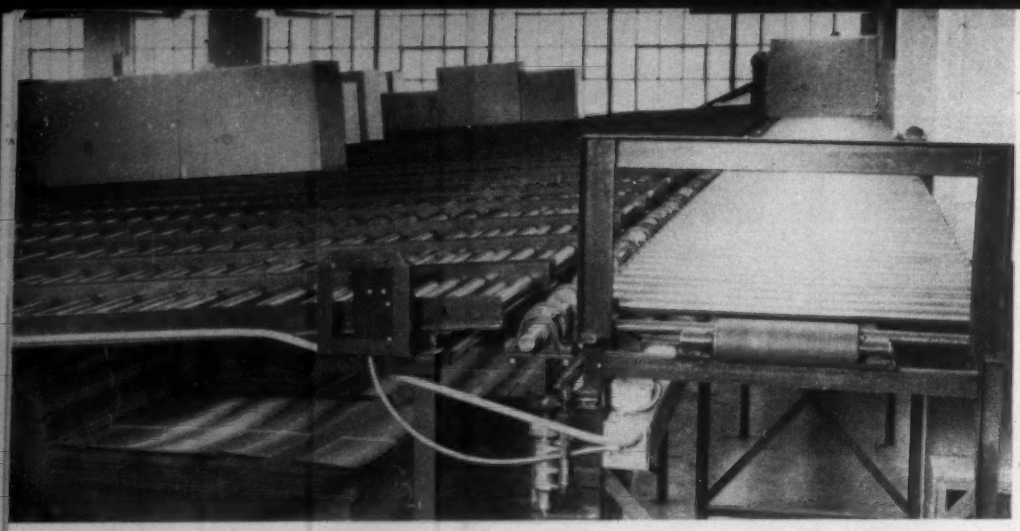

Fig. 4—Cartons leaving transfer station now move past picking racks. They are stopped at proper discharge point and unloaded by signals from DASAC

up to five containers, thus providing plenty of reserve for the order picker.

Since the handler in the warehouse can dispatch to any rack, the picker no longer has to perform the assorting operation (placing color of blouses in sequence). Thus a style containing six colors is automatically assorted as it is lined up on the racks.

Color	Rack No.
White	4
Blue	5
Red	6
Pink	7
Aqua	8
Green	9

The space required for the bank of gravity racks, tilt section, order picking aisle and belt conveyor bringing picked goods to the packers is 1696 square feet. However, 850 square feet of the space under the gravity racks is used for storage of shipping cartons so that the total space used for all the above operations is only 846 square feet—a reduction in footage required of 66 per cent.

A return conveyor running under the tilt section takes back to the warehouse all empty containers and unused goods. A belt conveyor running parallel to the picking aisle takes the picked goods to the packers. Walking time which formerly represented 76 per cent of the order picking has been reduced to 6 per cent. Confusion formerly caused by materials handlers, assorters and pickers all using the same aisle has been eliminated since only the pickers use the aisle.

▶ Control with a Memory

The basis of the selecting and dispatching control system is DASAC. When bulk containers are placed on the dispatching conveyor, *Fig.* 2, the operator presses the pushbutton which corresponds to the rack to which the container is to be delivered. The selections are recorded and memorized by DASAC in the exact sequence in which the containers are placed on the first conveyor. The containers then travel, *Fig.* 3, to a transfer point where they await a release signal from DASAC.

As soon as destination selections are recorded, the transfer section is energized, the bulk container is then shifted by the transfer unit to the powered roller distribution conveyor. As the container moves down the powered roller conveyor, signals are fed back to DASAC which checks them against the selected destination. When the container reaches its discharge point, a circuit is established which stops the powered rolls, *Fig.* 4, and sets the rack pull-off mechanism into action. To make certain that the container has cleared the pull-off mechanism, a timed electric eye is used. When the container has passed through the photoelectric beam, a signal is transmitted to DASAC to erase that selection from its memory and send the next selection into the transfer unit.

At the bottom end of each picking rack is a tilt section, *Fig.* 5, so designed that when it is in a horizontal plane, only one container can enter this section. By returning the tilt section to a vertical plane, the order picker is then ready to use the contents for order selection. The requirements of

THE AUTHORS

ALLAN HARVEY and SOL TANNE are consulting engineers with the Dasol Corp., a firm with "practical automation" as the primary objective. To them practical automation represents an approach whereby automation is applied to that process or part of a process which is ready to absorb the technological advance which is synonymous with automation. In designing and building the controls, they prefer to use stable and proved components rather than let imagination roam. They are specializing in applications involving warehouse, shipping and materials handling problems and in order picking, selections, routing and dispatching systems.

the individual customer orders are picked from the various open containers and stacked as an order unit. These stacks move by belt conveyor to the packing section where they are placed in shipping containers. The cartons are placed on the sealer distribution rack by size, *Fig.* 6, and run through the case sealer, *Fig.* 7, in lots of each particular size.

DASAC maintains a perpetual inventory of all containers on every picking rack and includes in that inventory all containers which are in transit. When the number of selections raises the rack inventory to its maximum value, a red *Full* signal appears above the rack selection button, *Fig.* 8, and the pushbutton becomes nonoperative. Safety features include warning signals should a carton fail to clear the exit eye. In addition, an error correction circuit is included. An indicator panel located on an upper level of DASAC gives a visual pattern of the container destination and the progress of the container along the distribution conveyor until it reaches the discharge point.

Functions of Control

In the operation DASAC performs three basic functions. First, there is the selection of the container destination and addition to the inventory. One bank of step-switches working with fast-acting relays performs this function. It is important to make the stepping of the relays and switches independent of the length of time it takes for the operator to push the select button. Special add-and-subtract counters are used to keep up to the minute inventory. These are tied into both the previous select relay circuits and the tilt sections associated with the sorting racks.

The second phase consists of memorizing the selections in consecutive order. Two banks of step switches under the control of relays pick up the calls and record them for future use. Should there be an error in selections, an independent relay circuit allows the error to be erased and deducted from the inventory of that particular rack.

The third and last phase is the read section. A group of step-switches co-ordinates the information relayed by limit switches at the individual rack and the selections retained in the memory levels of the previous circuits. Motor control relay circuits are energized to stop the container at its proper discharge point and effectively send the container down its rack over a specially designed pull-off friction wheel drive. Erase levels then delete the section from the memory. The stepping levels of the read section wait for the signal that the container has passed the eye before carrying out the next selection. Separate levels in the step switch circuitry guard against asynchronous troubles by giving a visual indication of the causes as well as preventing any further error.

In all, DASAC contains approximately 250 plug-in relays, *Fig.* 9, step-switches, add-and-subtract

Fig. 5—Containers are upended one at a time for order picking operation. Return conveyors below remove empty cartons and material for reshipment to warehouse. Picked orders are placed on collection belt transporting them to packers

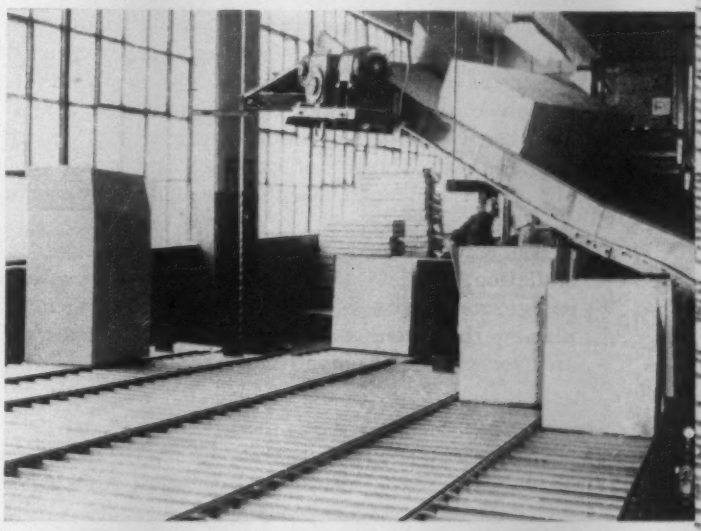

Fig. 6—Leaving the packing section different sized cartons enter sealer distribution racks waiting proper turn for sealing. Return conveyor rises over sealing section

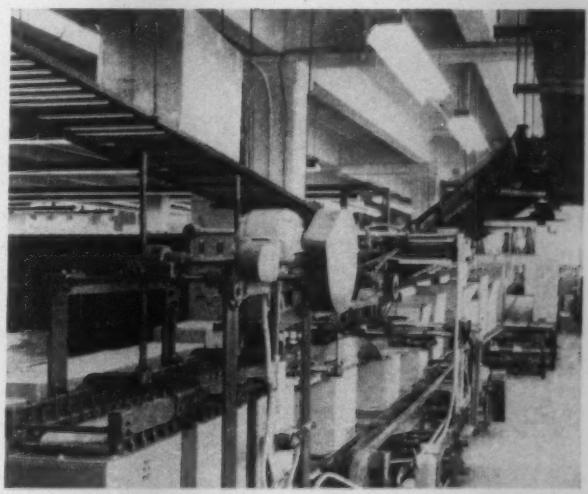

Fig. 7—When sealer distribution rack for any one size is full, cartons leave rack and enter case sealer for final sealing operation

counters, and over four miles of wire. The unit is engineered for minimum maintenance, *Fig.* 10, by using standard plug-in units which can be switched around on-the-spot for trouble shooting and easy replacement. Wiring is color-coded for rapid circuit tracing and terminates in terminal blocks for rapid component replacements. All parts are readily accessible through rear doors or removable front panels.

Practical Automation

This is automation at a practical level. It is designed to handle a particular set of problems which represent the "one best way" for Judy Bond. It is practical because in achieving this automation no radical or spectacular techniques were used. Sound engineering analysis of the problems to be solved, were followed by design of the control unit keeping in mind the requirements of simple maintenance. The use of standard and stable components has made it possible to bring automation to an everyday level.

The employees at Judy Bond welcome this installation. It has made their work easier and safeguarded their jobs by effecting economies and placing their company in a position to deal with an ever growing competitive market.

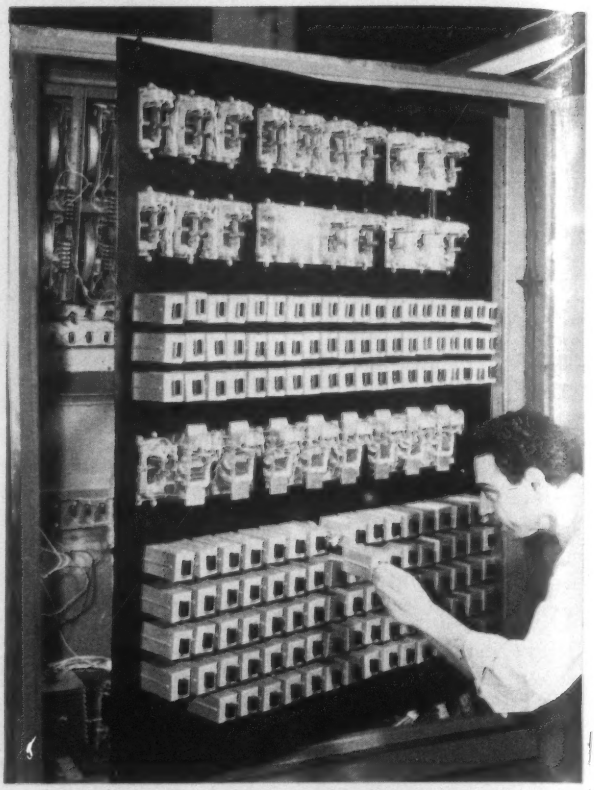

Fig. 9—Relays are covered, all components are accessible for quick inspection and maintenance

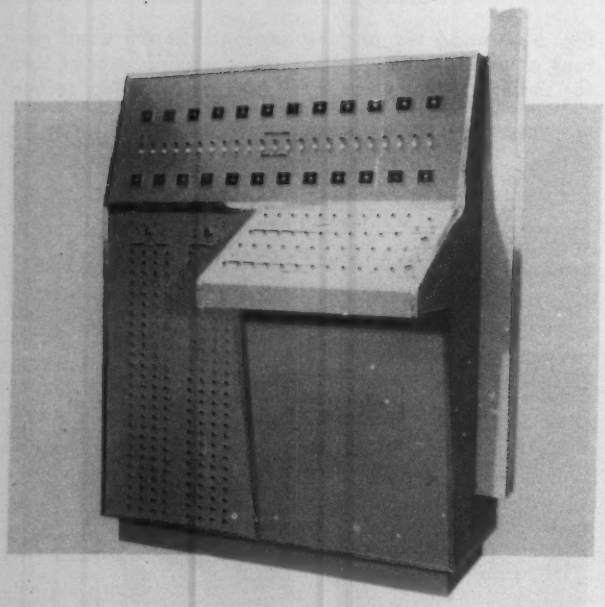

Fig 8—DASAC unit showing pushbutton selectors, full rack signals, inventory recorders on upper panel and other visual signals for carton location and destination

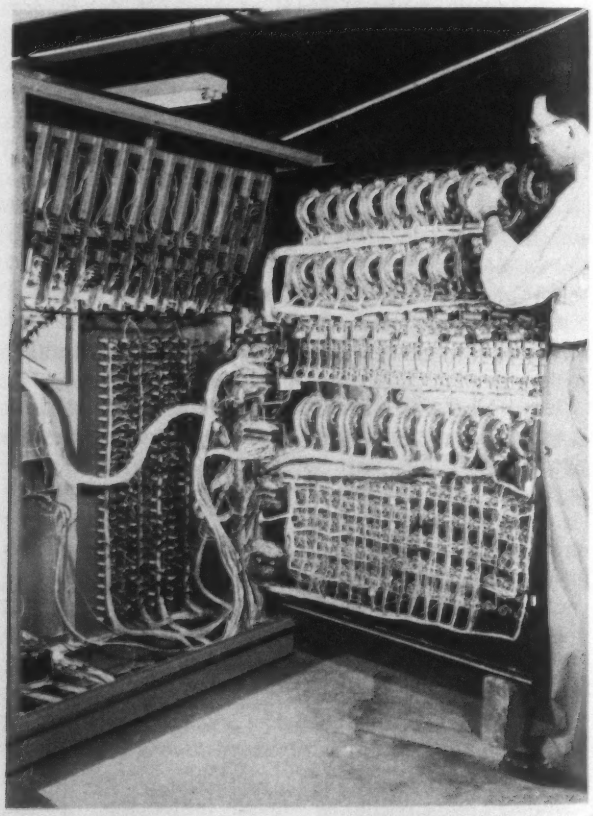

Fig. 10—View of inner workings of DASAC, showing interconnection of step-switch banks, relay levels, indicators and counters

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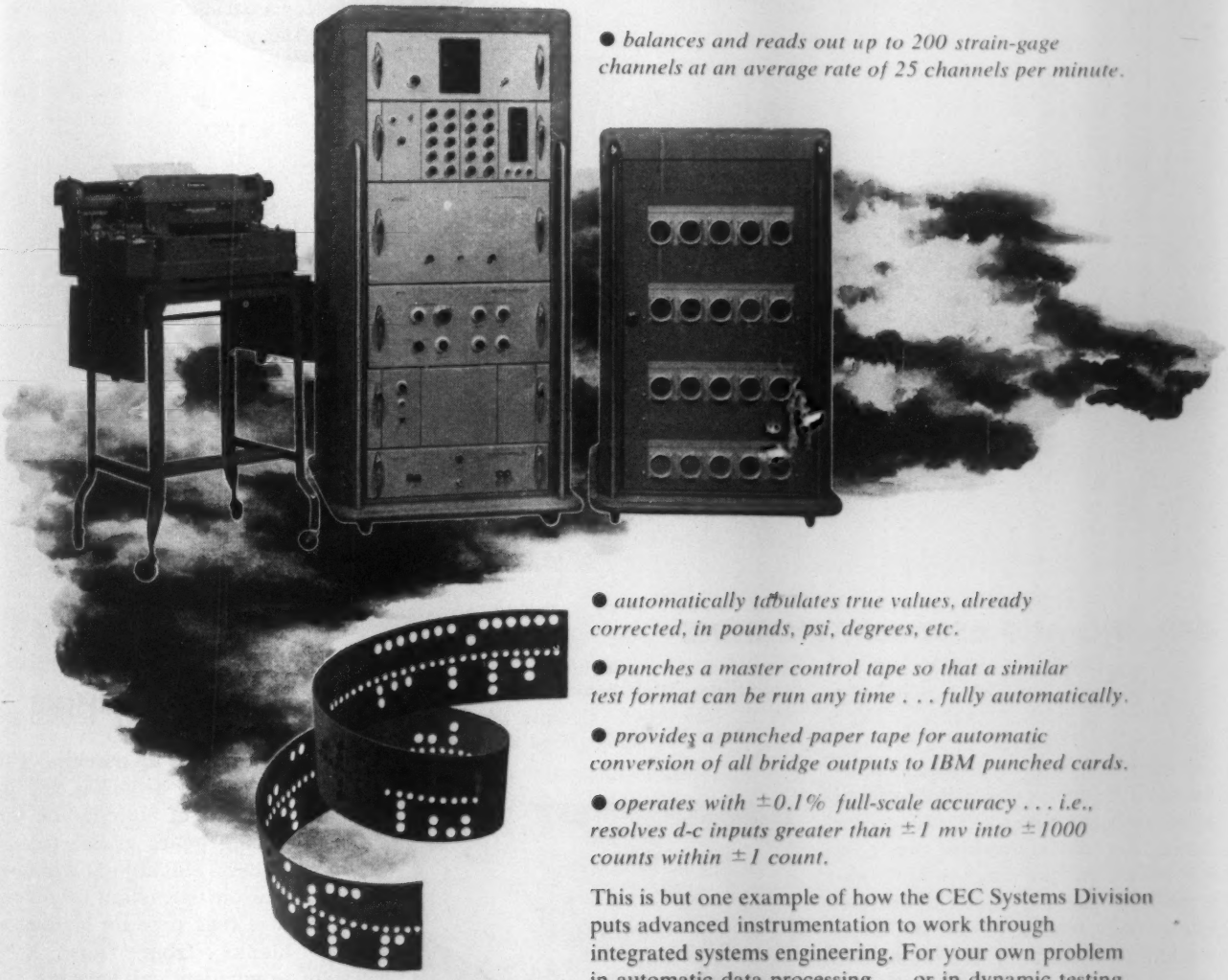

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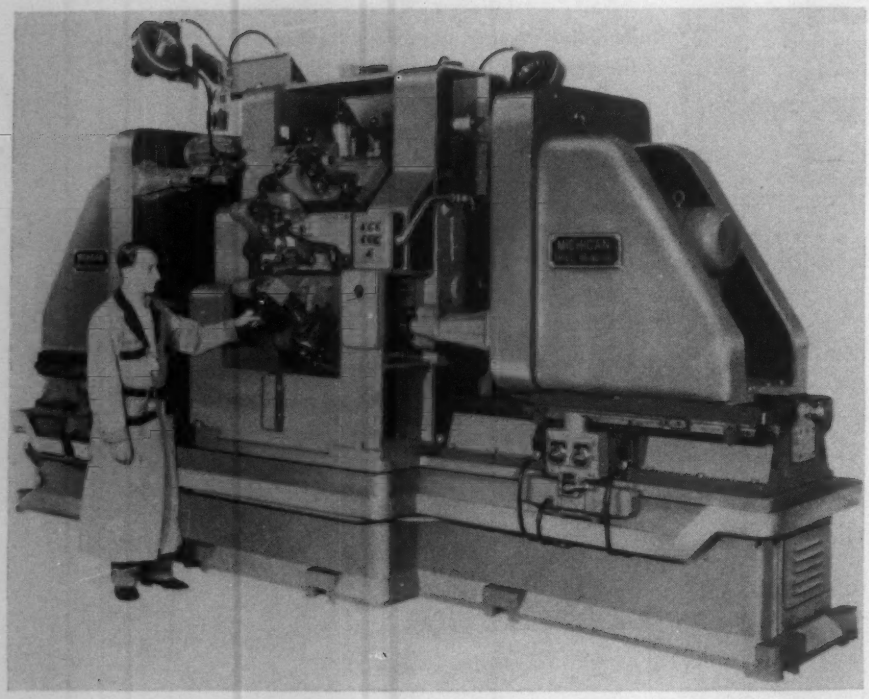

DRILLING AND ASSEMBLY MACHINE

Double end drilling and assembly machine with a trunnion type index table performs both machining and assembly operations automatically. Index table is mounted in a vertical plane to save floor space. Automatic machine produces 120 manifolds per hour, with bushings and pin in place. The machine drills two holes for the heat-control butterfly in the manifold, reams the two holes and drills the stop pin hole. Next, it hopper feeds two bushings, presses the two bushings in place and stakes them. Finally, it reams the two bushings, hopper feeds the pin and presses the pin into place. All units in the drilling and assembly machine are hydraulically operated and automatically lubricated. The ways are hardened and ground. For changing of parts or models, center section is accessible for conversion or retooling. **Michigan Drill Head Co.**, P. O. Box 4643, Detroit 34, Mich.

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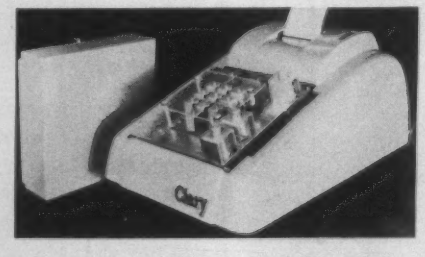

DIGITAL READOUT

Designed for printing data in electrical impulse form, digital readout machine is available in four models of 8 and 10-column printers, two with credit balance accumulator. Pulses may be entered into the amount solenoids at speeds up to 40 milliseconds total pulse resolution with 20 milliseconds on time. Solenoids are available for operation on 24 v dc, 48 v dc, 110 v ac or dc. **Clary Multiplier Corp.**, San Gabriel, Calif.

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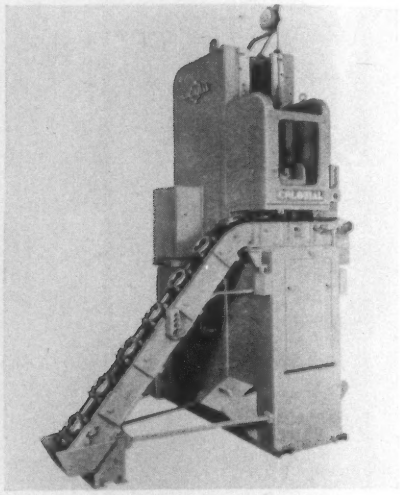

BROACHING MACHINE

New 15-ton pull up machine with a 48-inch stroke broaches the inside diameters of automobile differential ring gears at the rate of 300 per hour. Machine is equipped with an automatic, chain type loading fixture that permits loading of gear blanks from floor level. Twenty-two identical locating fixtures and 22 broach return gaps are spaced alternately along the double chain loading conveyor. Conveyor is driven hydraulically and indexed every half machine cycle—once for the cutting stroke and once for the broach return stroke. Broached blanks are gravity unloaded as the conveyor sweeps around the sprockets at the unloading station. Hydraulic and electrical circuits are interlocked

for timing and safety. To avoid signal overlapping or lag, index limiting switch is placed as close to the broaching station as possible. Limit switch is actuated by cams on the chain linkage at each of the 44 conveyor sections as they pass the broaching station, avoiding errors that might be introduced by slack in the conveyor chain linkage. **Colonial Broach Co.**, P. O. Box 37, Harper Station, Detroit 13, Mich.

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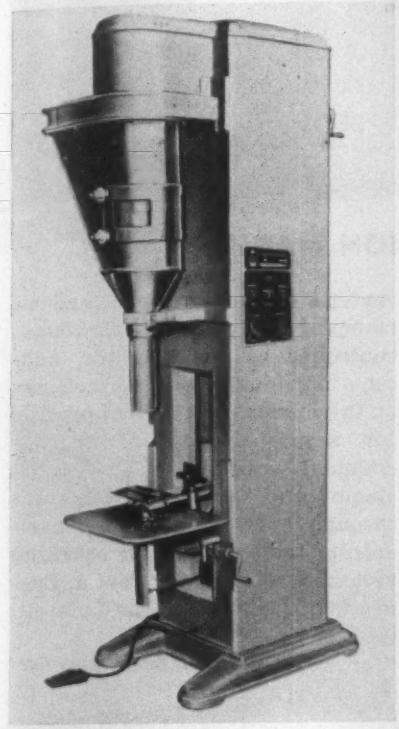

FILLING MACHINE

Designed for volumetric filling, pressure packaging, gross weighing or combination auger vacuum weighing, filling machine's capacity ranges from ⅛-oz to 5 lb. Universal filler handles powder, paste and granular products. Micrometer adjustment control affords accurate filling of cans, jars, boxes, bags and other containers. Driving mechanism in filler is located above filling station for cleanliness. Unit has no cams or sprockets, and magnetic clutch is self-adjusting. Auger speed is adjustable from 500 to 1000 rpm; filling cycle can be pretimed to pace operator from 15 to 30 units per minute. **Stokes & Smith Co.**, 4900 Summerdale Ave., Philadelphia 24, Pa.

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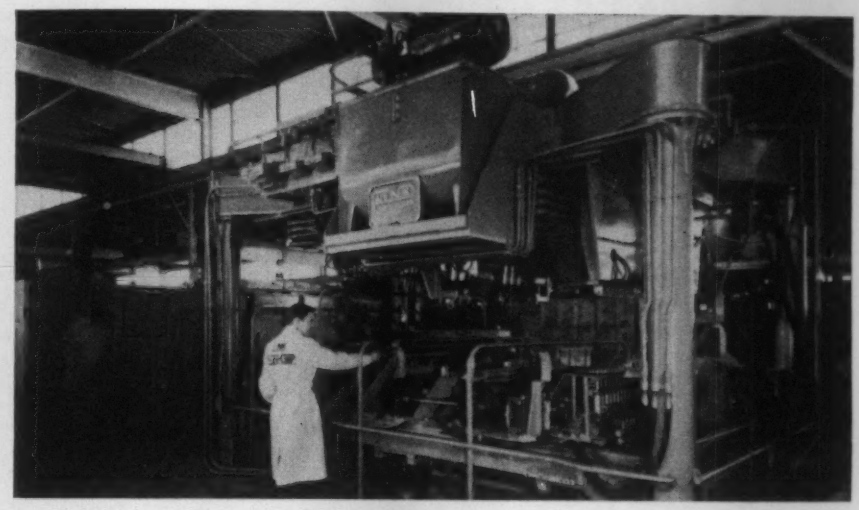

RESISTANCE WELDING PRESSES

Line of resistance welding presses is adaptable to the automotive field and a variety of sheet metal fabrication and end product manufacture in industries such as aircraft, furniture, chemical processing, utensil and plumbing fixtures. First series of these welding machines is being used to fabricate floor panel assemblies for an automobile manufacturer. One machine welds floor panels for convertible, two-door, four-door and station wagon models. Because of the difference in brackets, seat risers, etc., the floor panel differs completely from model to model. The operator of the resistance welder turns a switch, causing the welding fixture to adjust itself and fabricate the selected floor panel assembly automatically. The welding fixture is automatically indexed from left to right and vice-versa, so that each gun welds two spots on each work piece. Designed to weld dash panel to front floor to rear panel, resistance welder produces approximately 120 assemblies per hour. Each press is equipped with an automatic ejector which "kicks" each panel assembly out of the machine after it is completely welded. The hydraulically operated welder press is equipped with an air-surge tank which eliminates the necessity of plant air supply and the problem of air exhaust. Operating power is through compression and expansion of air within the tank which also serves to counterbalance air cylinders. Among equipment included in welder is a four post mechanical welding press, an automatic lubrication system, an electrical sequence panel, six sets of linkage holding platen in position, hardened and ground rollers, and adjustable, hardened ways. Presses are of box channel construction and are available in a variety of sizes and capacities. **Link Welder Corp.**, 13684 W. Buena Vista, Detroit 27, Mich.

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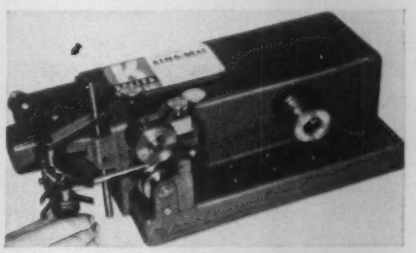

RING FORMER

Bench type, air operated tool automatically forms a ring of brazing wire directly on the part to be brazed. Rings are formed on the parts from a continuous roll of brazing wire or soft solder. As the ring is formed, the wire is cut automatically and another part is placed in position to be ringed. Unit forms rings from ¼ to 3-inches in diameter. Tool accommodates wire diameters from 0.015 to 0.062-inch. Continuous cycle operation takes one second to form

each ring. Among applications of ring former are brazing a spud into a formed sheet metal part, a bent tubing part to main assembly, a flange to pipe or rod, threaded bosses or studs to flat sheet metal part, and a pipe or tubing to threadless pipe fittings. **Keller Tool Co., Div., Gardner-Denver,** Grand Haven, Mich.

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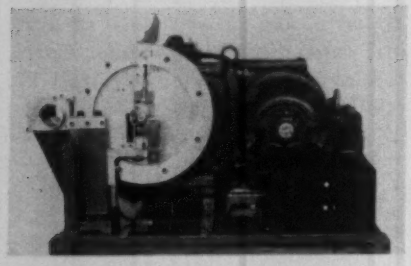
EXTRUSION CUTTER

Designed to handle plastics, rubber and soft wires, reinforced hose, impregnated fabrics, synthetic and natural fibers, and asbestos, electronically controlled extrusion cutter has blade capacities up to 2¼-inches. Machine will cut approximately 7000 pieces a minute. For large numbers of cuts per minute fixed knives are attached to the flywheel. Passage of the knife through the material is rapid because the blade in action travels at least 100 inches a second. This avoids backing up of material



against the knife or building up of internal back pressure which may distort a freshly extruded hollow section. Combination of electronic, electrical and mechanical elements in the controls permits stepless variation of the interval between cuts over the entire range from one cut every 6½-minutes to 7080 cuts in one minute. Among interchangeable knives available are angle mounted and saw blades, a "woodpecker" blade for tubes and shapes of larger diameters and very thin or brittle walls, 30 degree angle cutters for heavier material or those requiring exceptionally thin slicing, and a special arrangement for making 30 or 45 degree cuts instead of squarely across the extrusion. Multiple extrusions can be cut by using bushings to feed them to the knives. **Foster-Allen Corp.,** Garwood, N. J.

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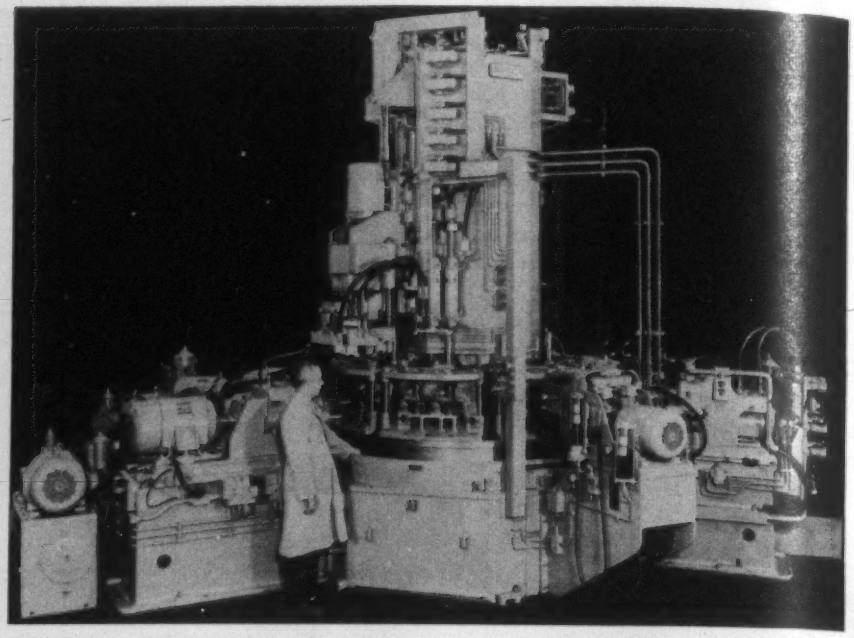

CENTER COLUMN AUTOMATION MACHINE

Eight-station machine featuring a 96-inch diameter index table is an addition to the line of Snyder center column equipment. High production machine tool (230 cast iron automotive steering gear housings per hour at 80 per cent efficiency) is designed for close tolerance boring, drilling, tapping, facing and line reaming operations. Fixtures on machine are large enough to permit mounting of two medium size production parts in each fixture and processing two parts at one time at each station. Machine is well adapted to carbide tooling applications on cast iron parts. The 14-ft high center column hardened and ground flat ways are long enough to provide adequate vertical head travel for accurate line reaming operations where tools are piloted in both bushing plate and fixture. Equalizing clamp fingers, which hold parts rigidly during machining, are provided on vertical heads on stations where core drilling work is required on parts with long unsupported length.

Table is indexed hydraulically through a fluid motor and gear train. Machine has a centralized lubrication system; fixtures are equipped with fittings permitting the operator to lubricate each one individually as required. Chain maintenance costs and excessive space requirements are said to be minimized with air counterweighted vertical heads. Clamping and unclamping of parts is pushbutton controlled by the operator. Adjacent individual hydraulic cylinders at the loading station are provided for separate clamping and unclamping functions. Cylinders clamp and unclamp the work through a rack and pinion mechanism, Acme screw and equalizing arrangement. **Snyder Tool & Engineering Co.,** 3400 E. Lafayette Ave., Detroit 7, Mich.

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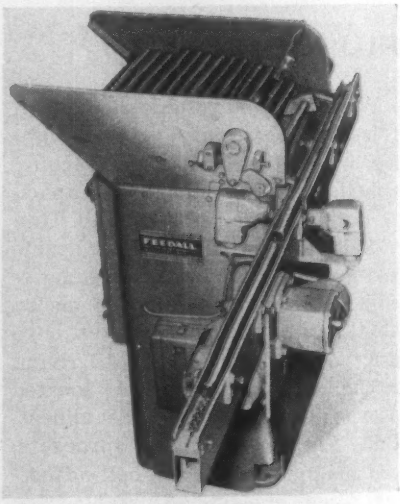

BAR FEEDER

New unit is designed to feed automatically, bars and tubes to centerless grinders, polishing ma-

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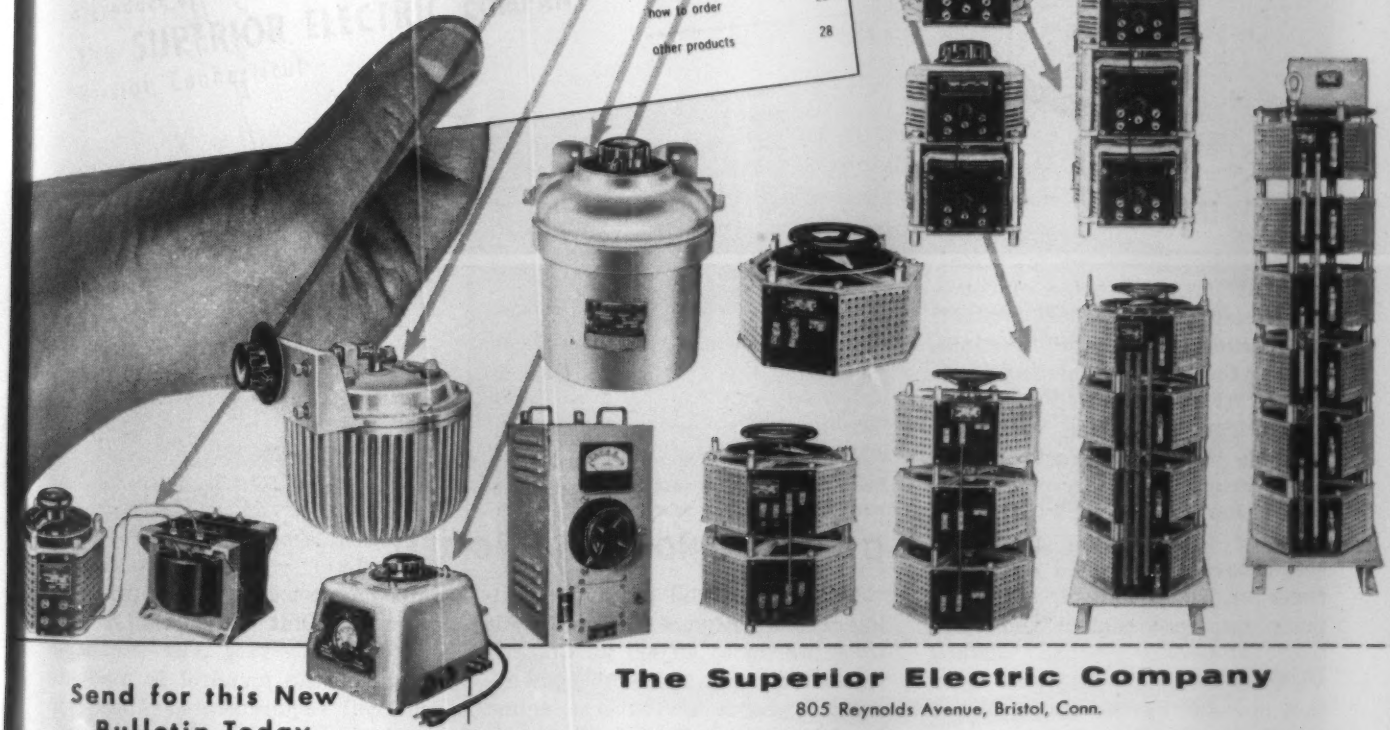

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chines, heat treating and hardening equipment. Illustrated model will convey parts ¼ to 1½-inch diameter and 6 to 26-inches long at a constant speed of 5 to 20 ft per minute from the hopper to the machine. Cycling control of the bar feeder can be either by photoelectric relay or mercury switch. Parts can be delivered as shown, or at right angles by use of special tooling. Other models which will convey parts up to 60 in. long at various feed rates are also available. **Feedall, Inc.,** Willoughby, O.

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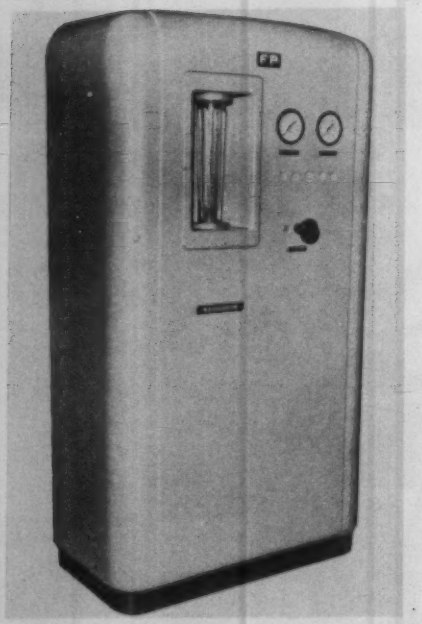


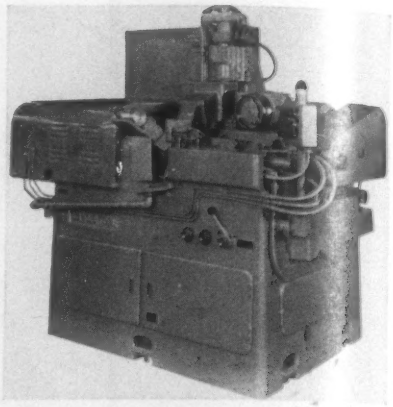
CHLORINATOR

Mechanically enclosed chlorinating machine constructed of corrosion resistant materials is available with several automatic functions. Among these are automatic proportioning by a transmitted pneumatic signal from an orifice, venturi or variable area flow meter, automatic proportioning by mechanical connection to a float in a flume, weir or tank, remote pneumatic set, program controlled operation, timer sequence control, automatic pump sequence control and automatic stop-start control. Manual adjustment of chlorine gas injection is made by the rate valve on the front of the cabinet, and actual flow rate is observed through the glass flow meter. Six metering tube and float combinations, interchangeable from the front of the cabinet, provide 10 to 1 or greater overlapping flow ranges from a minimum of 100 lb to a maximum of 8000 lb of chlorine gas per day. **Fischer & Porter Co.,** Hatboro, Pa.

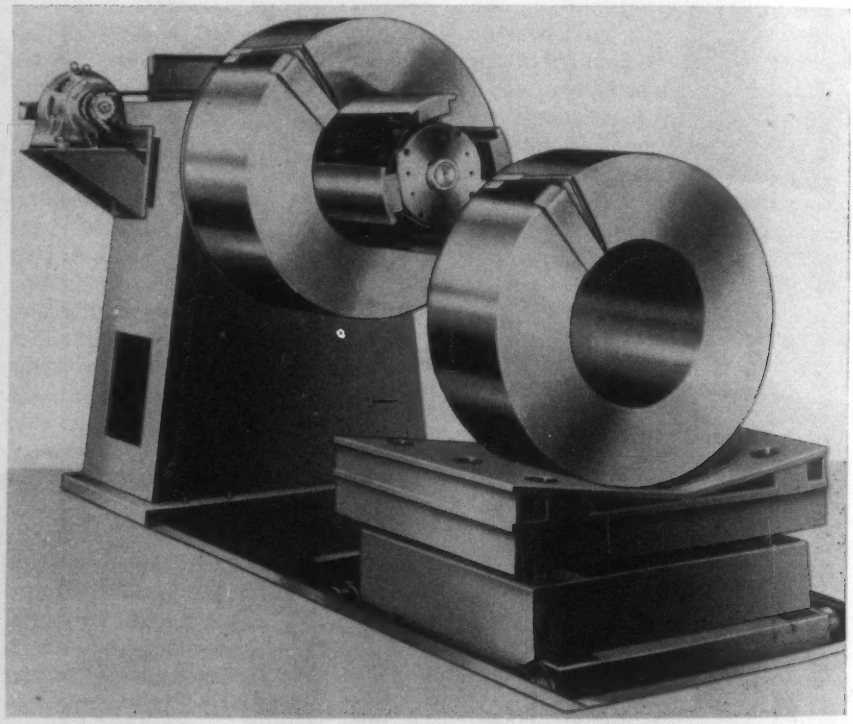
Circle No. **10** *on Reply Card*

PISTON GRINDER

Precision grinder automatically loads, grinds and discharges automotive pistons. Aluminum pistons are ground by the infeed method, using a wide wheel which reciprocates laterally during the grinding cycle. Master cam and rocking work-cradle produce elliptical pistons. Work head and grinding wheel spindles use Microsphere bearings which have one piece steel construction and babbitt lining and faces. Bearings are automatically lubricated. Motors for grinding wheel and work spindle require lubrication pressure to start, and will stop rotation in case of pressure failure. Use of conveyor and transfer mechanism with piston grinder makes system completely automatic. **Landis Tool Co.,** Waynesboro, Pa.



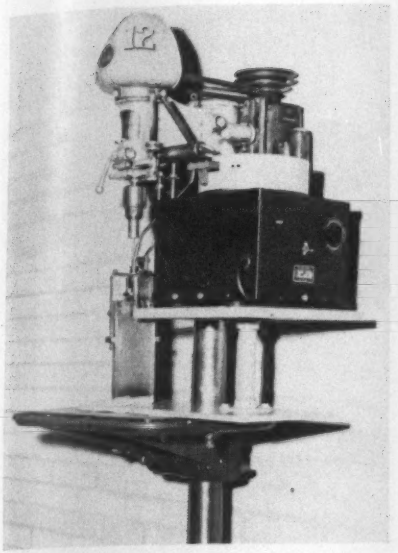
Circle No. **11** *on Reply Card*



COIL LIFT AND DECOILING REEL

Combination coil lift and decoiling reel is designed to handle coils weighing up to 40,000 lb. Coil lift is available with mechanical or hydraulic elevation. Traverse action is either by electric or hydraulic drive. Decoiling reel is free running or motorized for constant drive or for threading only. It is equipped with drag type brake to introduce tension to prevent overrunning. Unit is available in double cone-type reel. The expansion range of the mandrel is made to suit coil requirements. Units are available in combination or individually. **Dahlstrom Machine Works Inc.,** 4225 W. Belmont Ave., Chicago 41, Ill.

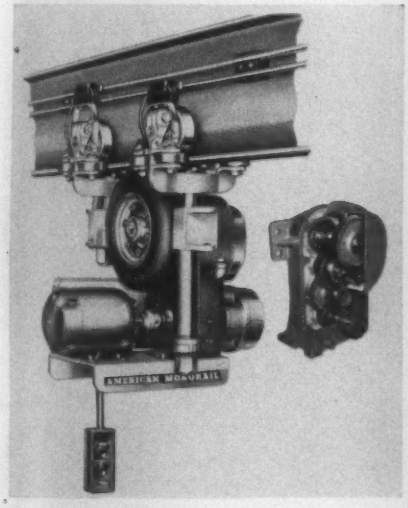
Circle No. **12** *on Reply Card*



SET SCREW FEEDER

Hopper-fed headless set screw device features automatic diameter inspection and rejection of misfits, ability to work with all metals and plastics on any product using headless set screws with a reduction of problems such as cross threading. Set screws are mechanically fed from a vibrating hopper, down through a tube and automatically positioned for driving by means of a roller device. **Set Screw & Mfg. Co.**, 266 Main St., Bartlett, Ill.

Circle No. **13** *on Reply Card*



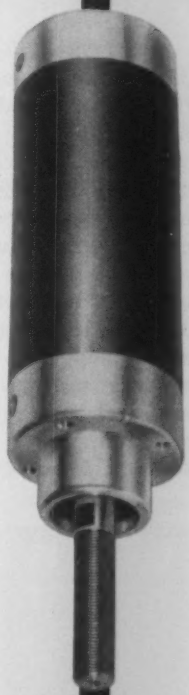
DRIVE UNIT

Drive unit is designed to propel a hoist or other type carrier on a monorail track or crane bridge. Traction is obtained by spring

NEW NP Power Drive Cylinder

. . . has all the "most wanted" design features

No other cylinder offers you so many vital features: compact, streamlined design; lightweight aluminum alloy and steel construction exceeds all strength requirements; interchangeable mountings — foot, flange, pivot, clevis and trunnion. Every cylinder can *operate with air, water or oil without interchanging or adding parts:* Adjustable cushioning (optional) can be added to any cylinder at any time.



PLUS

1. Sealed-in lubrication eliminates line lubricators.
2. Rod wiper and long, self-lubricating bronze rod bearing.
3. Self-compensating synthetic multiple "V" rod packing.
4. Rod packing and bearing externally removable.
5. Large porting gives quick response and smooth performance.
6. Rotatable end caps allow 360° piping location.
7. Rust-proofed cylinder tubing has tough I.D. surface.
8. Bronze piston bearing assures maximum support.
9. Ground and polished stainless steel piston rod.
10. Synthetic "U" cups automatically adjust for wear.

Mail this coupon for data sheets

INDUSTRIAL ACTUATORS AND CONTROLS DIVISION,
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston 19, Mass.

GENTLEMEN: Please send me complete information on

☐ NP Power Drive Cylinder ☐ NP Power Check feed control
☐ NP Power Trol valves

*Name*_____ *Title*_____

*Company*_____

*Street*_____

*City*_____ *Zone*____ *State*_____

NATIONAL PNEUMATIC CO., INC. AND **HOLTZER-CABOT** DIVISIONS

125 Amory St., Boston 19, Mass.
Sales Service Representatives in Principal Cities throughout the World

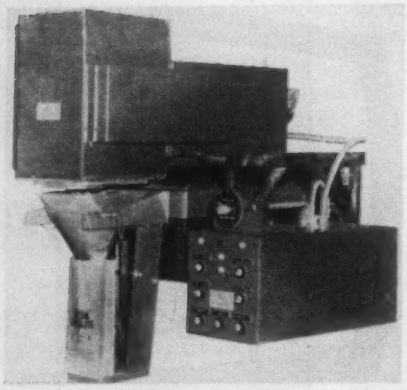
Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

loaded contact of the rubber wheel against the bottom of any smooth flange track. Among features of drive unit are life-time helical gearing, automatic adjustment for tire wear, and fluid drive for cushioned starting. Speed range is from 35 to 350 ft per minute; power range is from ¼ to 2 hp. **American Mono-Rail Co.**, 13107 Athens Ave., Cleveland 7, O.

Circle No. **14** *on Reply Card*

FILLING SCALE

Gross weighing scale handles powders which are extremely free flowing or flooding and fills directly into open mouth bags, cans or drums. Nonflooding feeder is designed to handle products ranging in density from 8 to 35 lb per cu ft. Among control arrangements available for the scale are a dust tight bag holder for use when handling toxic materials, and a small surge hopper which contains an agitator section, automatically assuring flow of material to the feeder. Filling scale may be used to fill 1, 2, 5, and 10 lb bags; a platform allows the unit to handle cans. Scale features a leverage system provided with special pivot plates, which are said to retain their original accuracy after many weighings. Unit can also be used as a net weighing scale for discharging preweighed loads to storage containers, or for batching purposes. **Thayer Scale & Engineering Corp.**, 494 E. Water St., Rockland, Mass.

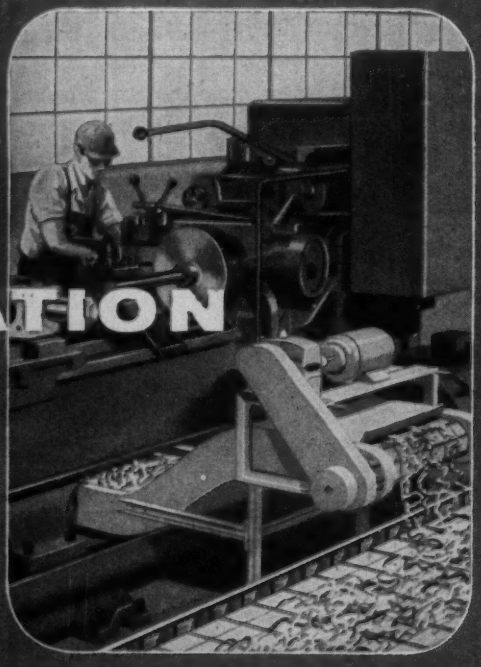


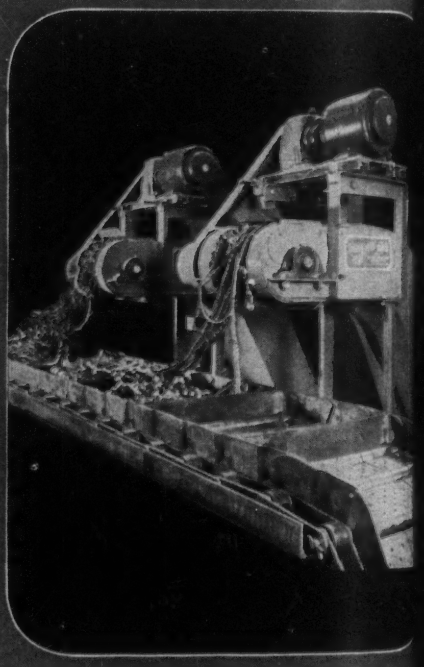
Circle No. **15** *on Reply Card*

SORTING GAGE

Semiautomatic, electronic sorting gage measures small curved parts and sorts them into several dimensional categories. Unit measures the chordal height of the curvature on thermostatic diaphragms and sorts them into six categories, plus oversize and undersize. Speed of the hand fed, timer controlled gage is approximately 2500 pieces per hour. In operating the gage, the operator places a workpiece over

May-Fran
...first
for
AUTOMATION
in
scrap
handling
systems





The CHIP-TOTE conveyor permits complete utilization of machine tools by eliminating shut-down for manual scrap removal.

It handles a continuous flow of hot, wet or dry chips, turnings and borings from any multiple spindle automatic machine.

the retracted reference anvil, and then presses the foot pedal. First, the reference anvil moves up to support the workpiece beneath the gaging contact. This contact, which is part of the electronic gage head, measures the chordal height and transmits the size signal to the electronic classifier. Classifier causes the trap door corresponding to the measurement to open, and after the reference anvil retracts, the operator slides the part into the correct disposal chute. Only one door is open at a time to prevent missorting. Each disposal unit is equipped with counters to record the inspected production. **Federal Products Corp.**, 1144 Eddy St., Providence 1, R. I.

Circle No. **16** *on Reply Card*

AUTOMATIC LATHES

designed for maximum carbide performance, high rates of metal removal and automatic chip removal, line of automatic lathes bores, faces and turns straight, tapered or contoured work. **Hydra-Feed Machine Tool Corp.**, 730 W. Eight Mile Rd., Ferndale, Mich.

Circle No. **17** *on Reply Card*

COLLAR PRESSING AIDS

improve collar, cuff and flap pressing in clothing and production. Solenoid permits automatic activation of pressing shoe for a predetermined length of time; interval timer permits machine to heat up at times set by the operator. **American Safety Table Co., Inc.**, 224 Fifth Ave., New York 1, N. Y.

Circle No. **18** *on Reply Card*

FILLER, HEAT SEALER

packaging machine, designed to fill and heat-seal closures on plastic containers at speeds up to 120 containers a minute, can handle all types of liquid products. **MRM Co.**, 191 Berry St., Brooklyn 11, N. Y.

Circle No. **19** *on Reply Card*

CONSOLE RECORDER

has direct writing oscillograph and flat frequency response from 0 to 80 cycles per second with compensated amplifiers, and is suitable for use with computers. **Photron Instrument Co.**, 6535 Detroit Ave., Cleveland 2, O.

Circle No. **20** *on Reply Card*

INFEED UNIT

designed for application on centerless grinders, provides automatic wheel dressing, diamond turning and coolant control. **Cleveland Industrial Tool Co., Inc.**, 1080 E. 222nd St., Cleveland 17, O.

Circle No. **21** *on Reply Card*

AUTOMATIC CHUCKER

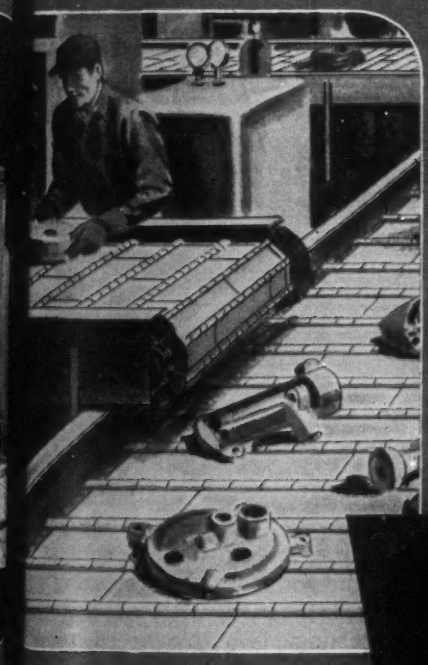
brings automatic control of entire machining operation to turret lathes. Open tooling zone and accessible chucking area of this 12-inch Universal Single Spindle Chucking Automatic provide room for automatic loading equipment. **National Acme Co.**, 170 E. 131st St., Cleveland 8, O.

Circle No. **22** *on Reply Card*

SPECTROPHOTOMETER

has wave length range extended to include near infrared and is adapted to study special sources and samples encountered in fluorescence, reflectance and polarization measurements, and in studies of flame and emission sources. **Applied Physics Corp.**, Pasadena, Calif.

Circle No. **23** *on Reply Card*



Hinged-steel belting handles scrap as well as hot heavy and abrasive castings. Belt is economical . . . maintenance-free.

Now is the time to put AUTOMATION to work . . . Now is the time to cut production costs . . . May-Fran engineers design and build complete scrap handling systems for the automatic removal of machine turnings or chips. May-Fran conveyors will transmit scrap to ultimate point of disposal.

Press Scrap systems can be made completely automatic. Hinged-steel belt will take scrap from presses, handle it through blanking, shearing, forming and baling processes, and deliver it to rail cars.

May-Fran is prepared to engineer, fabricate and install complete conveyor systems to your specifications.

DESIGNERS AND ENGINEERS OF COMPLETE SCRAP HANDLING SYSTEMS

MAY-FRAN ENGINEERING, INC.

Write today for complete information on how an automatic scrap removal system will cut your production costs.

Bulletin MF-530 describes the new Hinged-Steel conveyor belt.

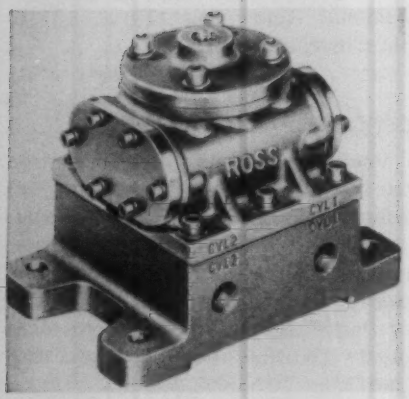
Bulletin MF-640 describes the Chip-Tote conveyor which removes scrap from operating machines.

5003-MF

1761 CLARKSTONE ROAD
CLEVELAND 14, OHIO

AUTOMATION new components

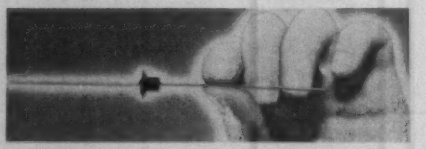
Parts, elements and devices designed for creating more automatic systems



Remote Controlled Valve

Four-way, base mounted, pressure valve is controlled by air from a remote pilot valve which may be hand, foot, cam, or solenoid actuated. Side ported models are available with ¼ through ¾-inch pipe sizes, and bottom ported valves fit 1 and 1¼-inch sizes. Main valve pressures can be as high as 125 psi, and pilot air pressures can be equal to or greater than the main valve pressure but not less than 30 psi. Actuation and reversal are immediate. **Dept. R1901, Ross Operating Valve Co.,** 120 E. Golden Gate, Detroit 3, Mich.

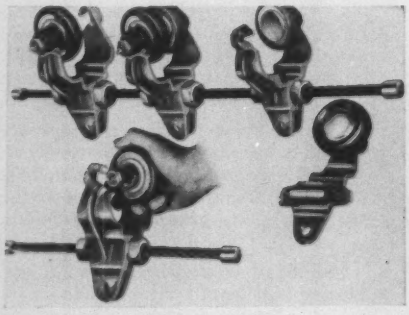
Circle No. 24 on Reply Card



Silicon Power Rectifiers

Designed for use in commercial equipment, magnetic amplifiers, meter protection, counter circuits and digital computers, silicon power rectifiers are also applicable in the automation and control engineering fields. Rectifier is small in size and weight and has low leakage and high rectification ratios. It will operate in high ambient temperatures and may be used without derating in ambient temperatures of 100C and higher. Maximum forward drop at full rating is less than 2 v with blocking voltages from 50 to 500 v in the standard ratings, and up to 1000 v on special applications. Rectification ratios run as high as 10^8. Forward voltage drops average 1.5 v at 200 ma. Several types and sizes of silicon power rectifiers rated from 100 to 500 ma are in production. **Bogue Electric Mfg. Co.,** Paterson, N. J.

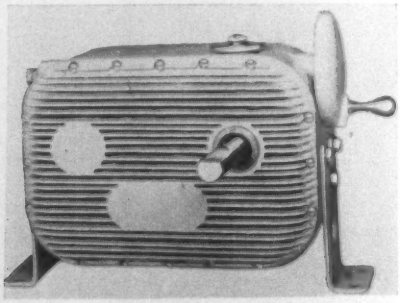
Circle No. 25 on Reply Card



Conveyor Trolley Bracket

New conveyor trolley bracket includes a removable wheel which permits wheel changes without dismantling or removing trolley from the monorail. Unit features a hook design at the top of the bracket arm. By loosening the retaining nut the wheel can be removed through the opening in the bracket hook; the replacement trolley can then be slipped through the opening in the hook. Once the wheel retaining nut is tightened, the trolley wheel will remain fixed in the proper position regardless of conveyor travel speed, suspended load or pull load. Indentations cast into the sides of the bracket hook and formed in the retaining washers aid in maintaining the wheel in position. Cable is available in 16, 24 and 32-inch links in accordance with trolley centers. Each link has swaged buttons on both ends which recess in the cavities of the cast malleable steel brackets. **American Cable-Link Co.,** 13446 Fenkell Ave., Detroit 27, Mich.

Circle No. 26 on Reply Card

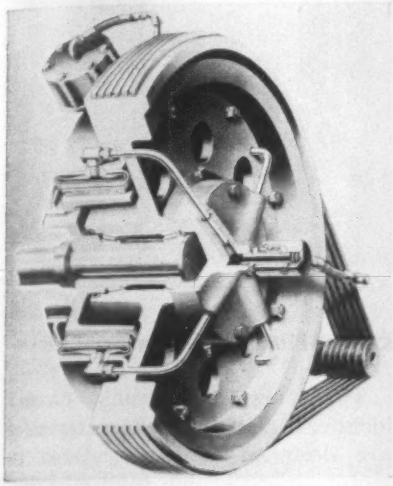


Variable Speed Reducer

Designed for use on machine tools, conveyors, packaging equipment, pump drives, metering equipment and other needs requiring wide speed range with accurate speed change, variable speed reducer has a constant torque rating of 100 inch-lb and operates on ¾ hp at 450 rpm. Unit gives full variable speed from zero to ¼ the input speed, weighs 25 lb and measures 7¼ by 10¼ by 6⅝

inches excluding shafts and brackets. Speed reducer features a screw handwheel for speed change, four-way mounting brackets for ease of installation and instant speed change at any time whether running or not. **Revco Inc.,** Dept. A., 2 E. Franklin Ave., Minneapolis 4, Minn.

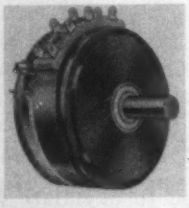
Circle No. **27** *on Reply Card*



Clutch-Brake Package

Designed for users and manufacturers of open back inclinable and straight side presses, new application features clutch and brake in a packaged arrangement, including a flywheel mounted on antifriction bearings, components and electropneumatic controls. Application is said to make possible press modernization for automation and increased production. Packages are made in seven sizes, adaptable to presses, ranging from 15-ton capacity to 110-ton capacity. **Fawick Airflex Div., Fawick Corp.,** 9919 Clinton Rd., Cleveland 11, O.

Circle No. **28** *on Reply Card*



Precision Potentiometers

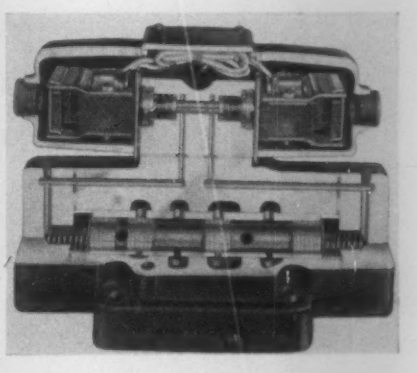
Engineered to meet nonlinear requirements, precision potentiometers have an operating range of −55 to 90C. During manufacture, as many as 25 potentiometers may be put on a common shaft, and 13 tap connections can be added to each potentiometer. Each tap is spot welded to a single turn of resistance wire. Potentiometer has external clamps for rapid phasing. Unit is 1¾-inch diameter by 0.8-inch length with a ¼-inch shaft. Power rating is above 5 w at 25C, above 4 w at 40C and 2.5 w up to 60C. Mechanical rotation is 360 degrees continuous; maximum electrical contact angle is 345 degrees, effective electrical rotation is 325 degrees. **Helipot Corp.,** 916 Meridian Ave., S. Pasadena, Calif.

Circle No. **29** *on Reply Card*

Dimpled Hinged Steel Conveyor

Designed to eliminate discharge problems experienced when handling small, flat, light gage metal parts or scrap, hinged steel conveyor belt features a dimpled surface. Dimpled design is said to assure drop off of flat pieces and scrap, even though covered with oil or compound or slightly magnetized. New belt handles small motor stator lamination knockouts, light gage automotive bushings and the like. Dimpled design is available in standard light duty 2½-inch pitch hinged steel belt, with dimples spaced on ¼-inch centers. Belting will handle hot, heavy and abrasive materials. **May-Fran Engineering Inc.,** 1761 Clarkstone Rd., Cleveland 12, O.

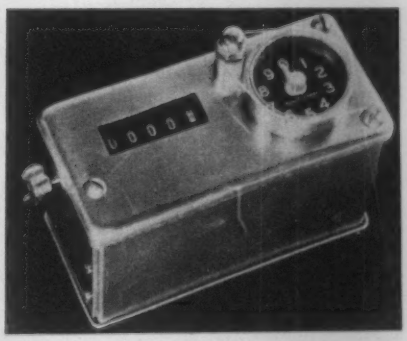
Circle No. **30** *on Reply Card*



Four-Way Valve

New four-way valve is solenoid controlled, pilot operated and subplate mounted. Models are spring-centered, spring-offset or no-spring, and can be converted from one type to another. Valve features concealed dust proof housing of the twin solenoids. Solenoids are fastened to the valve by the cover. When covers are removed, electrical operation cannot be made, thus insuring against loss of covers. Valve has a ¾-inch balanced piston, and operates at 2000 psi. **Racine Hydraulics & Machinery Inc.,** Racine, Wis.

Circle No. **31** *on Reply Card*

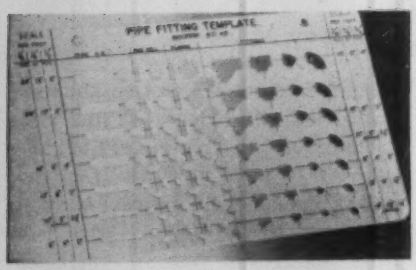


Pulse Counter

Developed for industrial counting and computer applications, pulse counter uses a six figure Veeder-Root register driven by a stepping motor, started and stopped magnetically each half cycle. Motor has one moving part which makes contact only with the ball bearings on which it rotates. Counter, called the Cyclonome, has a counting rate of 0 to 130 counts per second at an accuracy of ±½ count. Cyclonome will count dc pulses down to 3 milliseconds wide or ac cycles with a minimum half

cycle of 3 milliseconds. Photoelectric sensing equipment to drive the Cyclonome, adaptable to production and process counting, can be furnished. Stepping motor is available as a separate component, with either 1.3 or 2.6 inch-oz of torque output. Maximum stepping speed is 260 half steps per second. **Sigma Instruments Inc.**, 77 Pearl St., S Braintree, Boston 85, Mass.

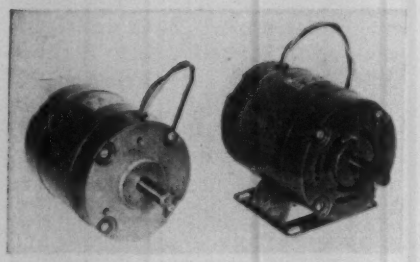
Circle No. **32** *on Reply Card*



Pipe Fitting Template

Designed for layout and detail drawings of piping systems using the double line, pipe fitting template is made of 0.030 matte finish plastic. Perspective views are made by using the ellipses for the different sizes of pipe diameters, bell diameters and flange diameters. Six different scales, each scale having six sizes of piping, ranging from 24-inch pipe diameter in ⅛-inch per ft scale to 1¼-inch pipe diameter in ¾-inch per ft scale, are found on the template. Size of the unit is 8 by 5⅛ inches. **Rapidesign Inc.**, P. O. Box 592, Glendale, Calif.

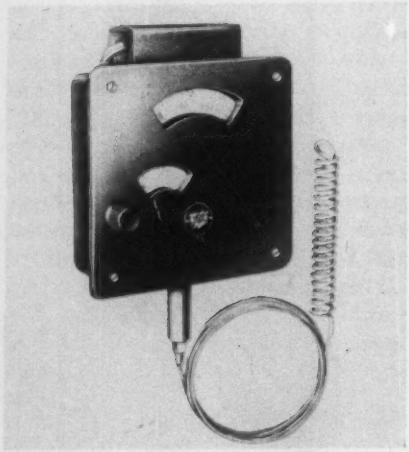
Circle No. **33** *on Reply Card*



Miniature Motors

Available as either hysteresis or ac induction units, new line of miniature motors features a built in "air conditioner" to give a low temperature rise with ratings up to 1/6 hp in a frame 4⅜ inches outside diameter by 5½ inches long. Among features of induction type motors are rotors that are insulated silicon steel, pressure die cast with 99.5 per cent aluminum. Hysteresis type motors have cobalt steel rotors, machined and heat treated, then fitted to aluminum spiders, pressed and pinned to the shaft. Internal fan, hardware and steel base are cadmium plated and dichromate sealed. Optional features available include shafts of different lengths, diameters and materials; total enclosure at reduced ratings for continuous duty or the same ratings for short duty cycles; balanced or unbalanced two-phase windings for short duty cycle. **Instrument Motors**, Box 5, Acosta St., Stamford, Conn.

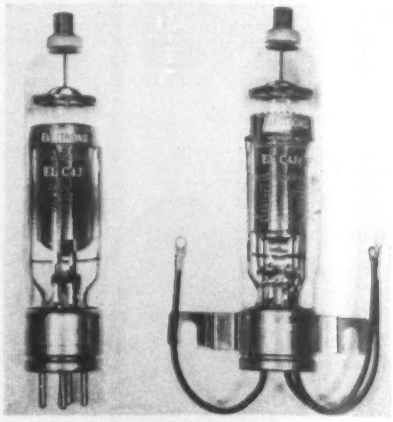
Circle No. **34** *on Reply Card*



Indicating Temperature Control

Designed for controlling and indicating temperatures of gases, liquids and hot plates within limits of −150C to 650F, new device has applications in incubators, water baths, mechanical convection or gravity type ovens, molding machines, and laboratory testing cabinets. Temperature control is said to reproduce accurately a master calibration in production quantities. A 12-inch revolving scale rotates against a fixed index pointer allowing readability and eliminating reading errors. Each model is automatically compensated for ambient and overtravel temperatures to maintain the control point at its calibration accuracy under all conditions met with controls of this type. Range spans vary from 300F or 550F with an approximate on-off differential as close as 0.5F. **United Electric Controls Co.**, 85 School St., Watertown 72, Mass.

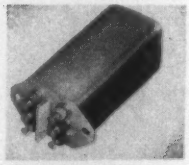
Circle No. **35** *on Reply Card*



Xenon Filled Thyratrons

Two new thyratrons having identical electrical characteristics are designed for applications in motor control and ignitor firing circuits. One model is designed for socket mounting; the other is for panel mounting wherever conventional sockets might not be desirable. Ratings of both models are 4 amp dc continuous average anode current; 30 amp oscillograph peak current with maximum peak forward and peak inverse of 900 v. Average arc drop is 12 v and heating time is 60 seconds. Stable grid characteristics are said to be maintained throughout life and critical grid current is less than 10 microamperes. **Electrons Inc.**, 127 Sussex Ave., Newark 3, N. J.

Circle No. **36** *on Reply Card*



Electronic Chopper

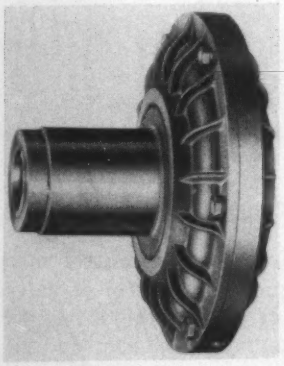
Designed to modulate dc to frequencies up to 400 cps, for a minimum life period of 3000 hours, new electronic chopper has no moving parts. Modulation is accomplished by illumination of a photoconductive element in a voltage divider.

Unit features temperature insensitive operation over a range of −50 to 100C; dc to ac conversion ratio over 0.5; noise pickup of less than 200 mu v rms; and 115 v, 3 ma ac excitation. Chopper measures ⅞-inch high by ⅞-inch wide by 2 inches long and weighs 1.6-oz. **Avion Instrument Corp.**, 299 State Highway No. 17, Paramus, N. J.

Circle No. 37 on Reply Card

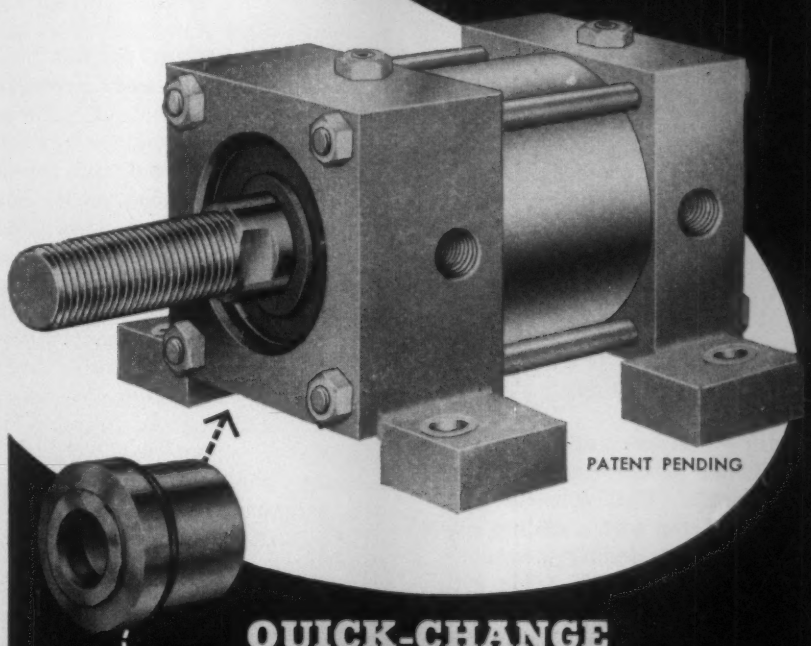
Dry Fluid Drive

Called Flexidyne, new dry fluid drive is used in industrial drives involving heavy inertia and shock loads on equipment such as compressors, centrifuges, conveyors, crushers and machines used in metal working plants, textile mills and oil fields. Flexidyne drive is made up of a housing, inside of which a rotor is free to turn concentrically. Between the two are fine particles of spherical steel shot, called the flow charge, which acts like a fluid. The flow charge transmits power from the housing to the rotor. In operation, the motor is connected to the housing, and starts it turning at no load. Flow charge is thrown to the circumference of the housing, is compressed by centrifugal force and revolves with the housing. Rotor, connected to the load, is started and accelerated by the friction and wedging action of the revolving flow charge. Rotor and housing reach identical speeds. Flexidyne operates with zero slippage between motor and load at normal running speeds. In case of an overload, rotor slips relative to the housing, overcoming the friction and wedging action of the flow



SP

*APPROVED HEAVY-DUTY AIR CYLINDERS for Automation



QUICK-CHANGE PACKING CARTRIDGE Cuts Downtime

Step up production with rugged, service-free, S-P Heavy-Duty Air Cylinders:

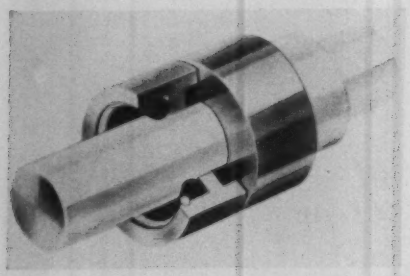
- Designed for 200 PSI
- Rolled steel end plates
- Extra long cushions
- Extra large, hardened piston rod
- Minimum mounting and envelope dimensions
- 5 types of mountings
- 8 bore sizes, 1½" to 6"
- Double porting
- Interchangeable check and cushion valves
- Quick-change packing and bearing cartridge

* S-P Automation Cylinders were designed expressly for a large automobile manufacturer. They are thoroughly proven for automation and general heavy-duty applications. Prompt deliveries. Send for Catalog 109. For S-P standard Air Cylinders, request Catalog 102. The S-P Manufacturing Corp., 12415 Euclid Ave., Cleveland 6, Ohio.

SP THE S-P MFG. CORP. — Cleveland
A Bassett Company
PRECISION PRODUCTS SINCE 1916
AIR AND HYDRAULIC CYLINDERS • POWER CHUCKS • ROTATING AIR CYLINDERS
COLLET AND DRILL PRESS CHUCKS • AIR PISTONS, VALVES AND ACCESSORIES

charge. A thermal switch is available which automatically cuts the electrical circuit to the motor if an overload persists. Flexidyne can be set to slip at anywhere from 20 per cent over full load torque to peak motor torque. Flexidyne is available in drives for mounting on motor shafts and in couplings with taper lock bushings for straight line drives. **Dodge Mfg. Corp.**, Mishawaka, Ind.

Circle No. **38** *on Reply Card*



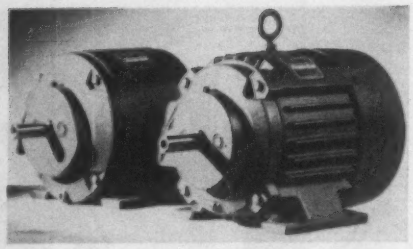
Magnetic Shaft Seals

Rotary seal prevents escape of fluids under pressure around a rotating shaft. Unit consists of a magnetized ring with a sealing surface, fixed in stationary manner to the housing and a second ring with a sealing surface, coupled to the shaft for rotation by means of an O ring. Second ring is movable axially along the shaft in response to magnetic attraction until it engages the first ring. Sealing surfaces are held in contact by magnetic force when no fluid pressure exists, eliminating the spring previously used. Equal distribution of pressure on seal maintains proper alignment of sealing faces, assuring sealing with minimum friction. Shaft seals are effective under pressures up to 3000 psi and temperatures up to 500F. **Magnetic Seal Corp.**, Higgins St., Georgiaville, R. I.

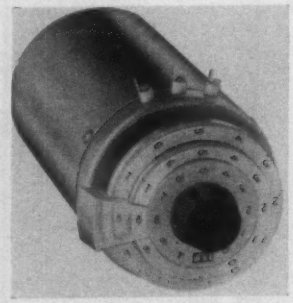
Circle No. **39** *on Reply Card*

Protected AC Motors

New line of ac motors features complete protection against drip, splash and falling objects regardless of mounting positions. Ventilation louvers are positioned in the end brackets; frame extends beyond coil heads to give full protection to the windings. Brackets ensure shockproof shaft support by placing the bearing mountings closer to the frame. Neoprene gaskets afford a positive seal between the frame and conduit box. Gaskets have indexed pressure knobs to hold each lead. Three types of protected motors are fan cooled, corrosion proof and explosion proof. Fan cooled model has corrosion proof outer fans and cast iron conduit boxes; corrosion proof model features neoprene shaft slingers and optional stainless steel components; and explosion proof model contains brass shaft slingers affording five-direction labyrinth fits. Motors are designed for industries such as chemical, metalworking and textile. **Reliance Electric & Engineering Co.**, 1088 Ivanhoe Rd., Cleveland 10, O.



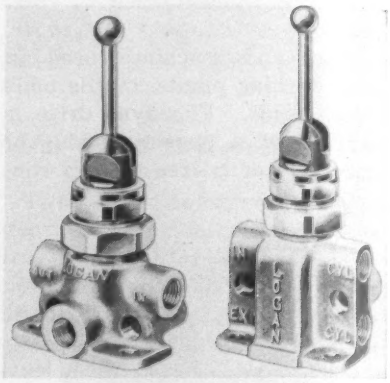
Circle No. **40** *on Reply Card*



Decade Capacitors

Designed for simple installation in computers and other equipment which require wide range rc networks, decade capacitors include a Dekadial which selects any incremental capacitance value throughout the 0 to 1 microfarad range within ± 1 per cent accuracy. Combination unit provides 1000 incremental steps of 0.001 microfarads each; direct capacitance readings are made on the stacked deck of dials. Dekadial's outer and middle dials have nine marked positions. Tenths and hundredths of microfarads respectively are selected by these dials. Unit is enclosed in a single cylindrical shield which has a 3-inch diameter and a 6-inch behind panel depth. Terminals are insulated from the metal shield by teflon bushings which serve as electrical tie points. Decade capacitors are used in servocontrol systems, filter systems, instrumentation, ac analyzer boards and computers. **Electro-Measurements Inc.**, 4312 S.E. Stark St., Portland 15, Oreg.

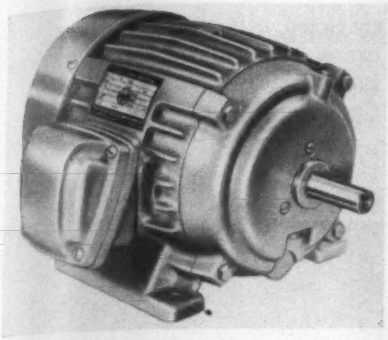
Circle No. **41** *on Reply Card*



Air Control Valves

Three new air control valves are designed for control of valves and cylinders. Model 6664 is designed for control of bleeder and pilot operated master valve. By removing plug in lower port, two-way valve is changed into three-way unit. Valve will lock in the off center position and is released manually to vertical position. Unit is designed for side or base mounting. Model 6665 is similar to first-model, but has two exhaust openings which permit bleeding both ends of the master valve alternately, providing automatic reversal when toggle lever is returned to normal position. Four-way, two-position valve with locking toggle lever, Model 6676, is designed for manual control of double acting air cylinders. Valve will lock at off center position to maintain position of cylinder at end of stroke. Manual or automatic release to vertical position reverses cylinder movement. **Logansport Machine Co. Inc.**, Logansport, Ind.

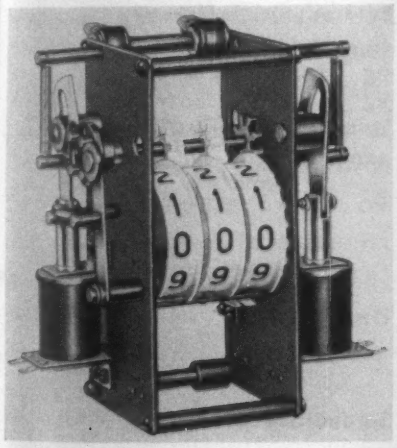
Circle No. **42** *on Reply Card*



Explosion Proof Motor

Designed to operate in dangerous locales which have highly inflammable gases, volatile liquids and combustible dusts, explosion proof motors rated at 1 to 5 hp are fully enclosed with special provision to guard against fire, dust and moisture. Conduit box is sealed, and is of heavy design with a split dome. Internal bearing caps are extended along the shaft to insure against sparks traveling to the exterior. Long rabbeted register fits give a complete seal of the bracket to the motor frame. Drain plug of double threaded design can be furnished at the bottom of the end bracket. **U.S. Electrical Motors Inc.,** Box 2058, Los Angeles 54, Calif.

Circle No. **43** *on Reply Card*



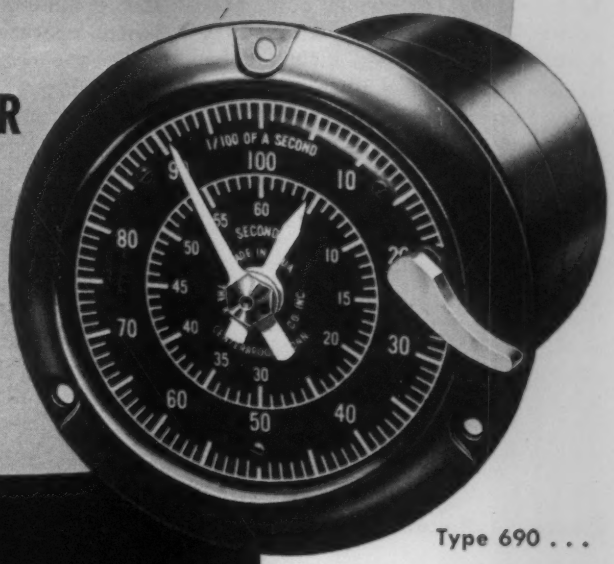
Automatic Counter

Ability to add and subtract makes automatic counter useful for operations which require maintaining of a set capacity, such as controlling flow of materials to machinery or conveyors, production and inventory, and control of physical capacity. Counter will

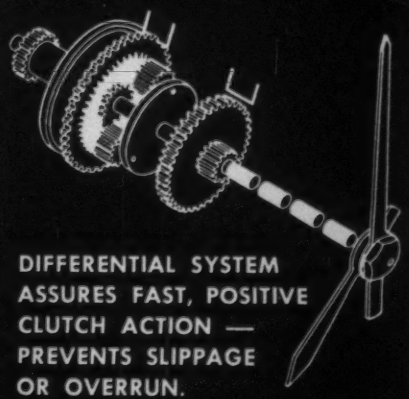
Cramer

TIME TOTALIZER

a highly accurate electrical stop clock . . .



Type 690 . . .



DIFFERENTIAL SYSTEM ASSURES FAST, POSITIVE CLUTCH ACTION — PREVENTS SLIPPAGE OR OVERRUN.

Positive engagement of pawl with gear combined with fine gear teeth provides the instant response necessary for a timing accuracy of ± .01 seconds on the 60-second timer, and ± .005 minutes on the 60-minute unit.

On the dial face, a large sweep hand makes possible fast, exact readings from the outer scale, while an accumulator pointer records larger time units on a separate scale in the center of the dial.

This compact unit is available for AC or DC operation in commercial and military applications. It is used in laboratory experimentation, for testing communications equipment and systems, and in the field of nuclear research, as well as for timing critical industrial processes.

For complete information on the Type 690, write for bulletin PB-610.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

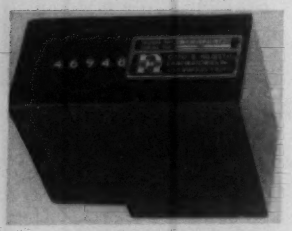
The R. W. CRAMER CO., Inc.

BOX 35, CENTERBROOK, CONNECTICUT

11CR55

count or subtract at a rate of 400 counts per minute, up or down, in any sequence, one count per impulse, maximum 999. It can be set at a predetermined figure to automatically shut off at zero. Unit may be actuated by a photoelectric cell, a tube, relay or a contact switch. Electrical coils are intermittent duty type—6 v to 110 v ac. Counter is 6½ inches wide by 3½ inches deep by 6½ inches high. **Spencer Mfg. Co.**, 3253 N. Cicero Ave., Chicago 41, Ill.

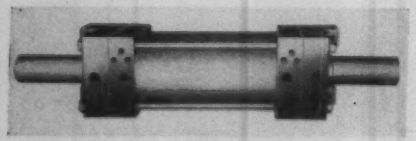
Circle No. **44** *on Reply Card*



Electrical Readout Counter

Pulse actuated electromagnetic counter which both adds and subtracts uses separate coils. Counters have a ½ w potentiometer which indicates the visual number by a proportional voltage connected to each of the five counter wheels. Among uses for units are on simplified telemetering systems, remote indicators, information storage with readout, inventory control and shaft digitizers. Counter operates up to 40 counts per second on dc. It is available for ac operation with a built in rectifier. Power requirement is 10 w, continuously rated; coils are wound to specification. **Nemeth Inc.**, 2223 S. Carmelina Ave., Los Angeles 64, Calif.

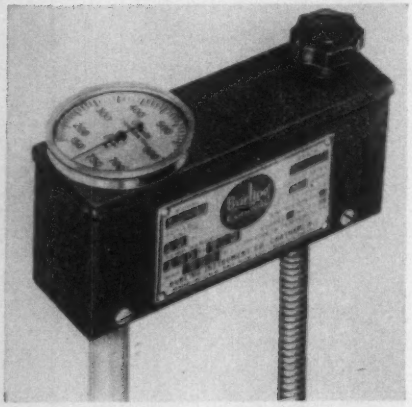
Circle No. **45** *on Reply Card*



Reciprocating Booster

Reciprocating booster is designed to deliver high pressure fluid for the operation of hydraulic cylinders. Unit operates from ordinary plant compressor air input, and consists of a double rod end air cylinder with a hydraulic discharge pressure chamber at each end. This cylinder enables booster to deliver a pressure output stroke in both directions. At the end of each stroke, piston assembly contacts an actuator button on the inside of the cylinder. Movement of the button operates the actuator which shifts the position of a four-way, two-position double pilot operated valve, causing the reversal of air flow and corresponding reversal of booster stroke. Unit is available in ratios to give pressures to 10,000 psi and over. Booster is used in operations requiring a high holding pressure without generating heat or wear and without consuming power. **Miller Fluid Power Co.**, 2040 N. Hawthorne Ave., Melrose Park, Ill.

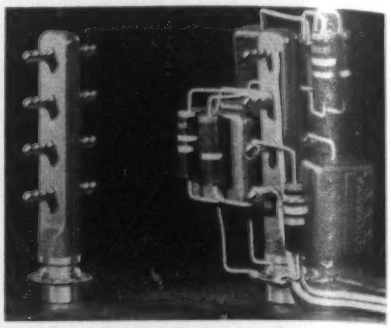
Circle No. **46** *on Reply Card*



Indicating Temperature Control

Designed for use in industrial ovens, dryers, liquid baths, ducts or laboratories, indicating temperature control combines an independent dial thermometer with a differential expansion type temperature control. Control is obtained by the differential expansion of two concentric tubes actuating a snap action switch through a lever. Switch is rated at 15 amp, 125 to 250 v ac. Operating differentials are from ±1 to 4 degrees, depending on conditions. Independent temperature reading is given by a bimetallic type dial thermometer with its stem inside and extending to the bottom of the inner control tube. Temperature control is designed for local mounting and may be furnished with flange or threaded fittings. The tube is of brass or stainless steel. **Barling Instrument Co.**, 16 River Rd., Chatham, N. J.

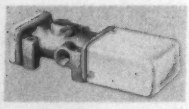
Circle No. **47** *on Reply Card*



Mounting Post

Designed as a mounting support for small components such as resistors, capacitors, diodes and transistors at their operating point in under chassis assemblies, mounting post is said to decrease likelihood of errors in model and production wiring in government and industrial units. Called the Tote-m-pole, this device aids engineers in getting near optimum component density and point to point wiring. Unit requires few leads, cables and soldered joints. Melamine pole gives mounting post low tracking, heat resistant properties. Tote-m-pole mounts with a single chassis drill hole. It is adapted to jig wiring practices whether the jig is of cardboard for design study or a production type. **Sangamo Electric Co.**, Springfield, Ill.

Circle No. **48** *on Reply Card*

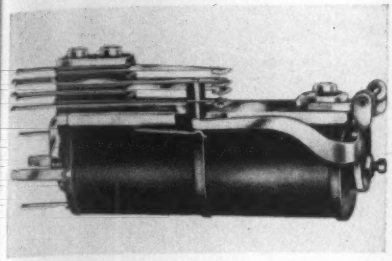


Solenoid Valves

Three-way series has been added to line of valves which includes four-way models. Solenoid controlled, pilot operated valves are available in ¼, ⅜ and ½-inch sizes for manual or electrical control. Same solenoid is used on all size valves, which have 115, 230 or 440 v operation. Mechanically actuated models include hand lever, clevis, roller, foot pedal and

treadle types. Actuators are interchangeable between valves of similar size. Torsion spring in the lever bracket returns valve when pressure is released. Spring can be removed when spring loading is not desired. Valve bodies are of cast bronze, and have inserted chrome plated stationary liners. A light weight aluminum spool is the only internal moving part. **Bellows Co.**, Akron, O.*

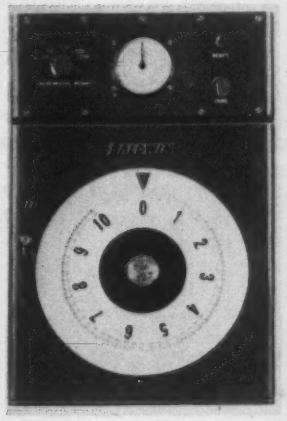
Circle No. **49** *on Reply Card*



Telephone Relays

New line of telephone relays is designed for applications requiring rapid opening and closing time of up to 14 individual circuits. Relay has dc operation and coil resistance up to 63,000 ohm. The coils are single or double wound with heavy hinge on single or double armatures. Unit features fast operating and release time. Maximum coil dissipation is 10 w. **Kurman Electric Co. Inc.**, 35-18 37th St., Long Island City, N. Y.

Circle No. **50** *on Reply Card*



Calibration System

Based on time and weight measurements, flowmeter calibration system is a specially designed indicator controller in which electrical indications of weight from the load cell start and stop a timer automatically at two preset weights of liquid after it flows through the flowmeter to be calibrated into a tank supported by the load cell. Illustrated instrument was designed for use with a precision type load cell of 1000 lb capacity. Weight dial (below) can be read within 1 lb and the timer dial (above) gives the time of flow to one-thousandth of a second. Empty tank weight is zeroed out on the weight dial and any of five incremental weights of 50 to 700 lb are set by means of a knob on the instrument panel. At the instant a specified weight of a liquid has flowed through the flowmeter into the tank, the timer is stopped automatically. **Baldwin-Lima-Hamilton Corp.**, Philadelphia 42, Pa.

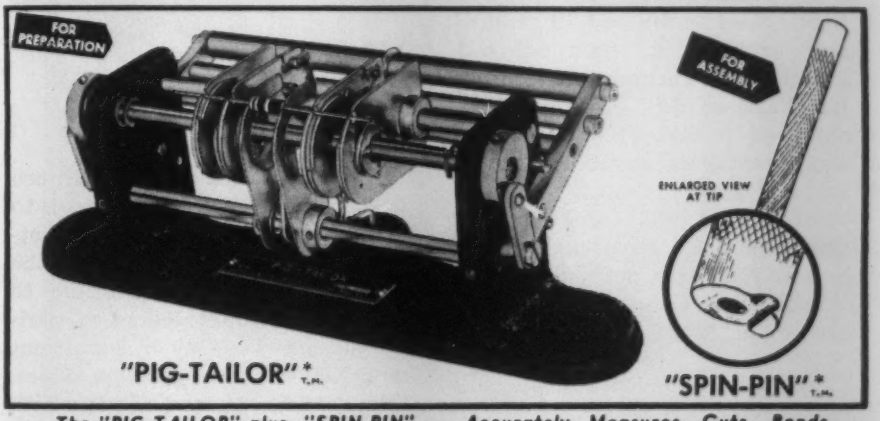
Circle No. **51** *on Reply Card*

Centering Tool

Called the spin roll, centering tool achieves concentricity for all metal components from zero up to

"PIG-TAILORING"

. . . . a revolutionary new mechanical process for higher production at lower costs. Fastest PREPARATION and ASSEMBLY of Resistors, Capacitors, Diodes and all other axial lead components for TERMINAL BOARDS, PRINTED CIRCUITS and MINIATURIZED ASSEMBLIES.



The "PIG-TAILOR" plus "SPIN-PIN" — Accurately Measures, Cuts, Bends, Ejects and Assembles both leads simultaneously to individual lengths and shapes — 3 minute set-up — No accessories — Foot operated — 1 hour training time.

PIG-TAILORING provides:

1. Uniform component position.
2. Uniform marking exposure.
3. Miniaturization spacing control.
4. "S" leads for terminals.
5. "U" leads for printed circuits.
6. Individual cut and bend lengths.
7. Better time/rate analysis.
8. Closer cost control.
9. Invaluable labor saving.
10. Immediate cost recovery.

PIG-TAILORING eliminates:

1. Diagonal cutters.
2. Long-nose pliers.
3. Operator judgment.
4. 90% operator training time.
5. Broken components
6. Broken leads.
7. Short circuits from clippings.
8. 65% chassis handling.
9. Excessive lead tautness.
10. Haphazard assembly methods.

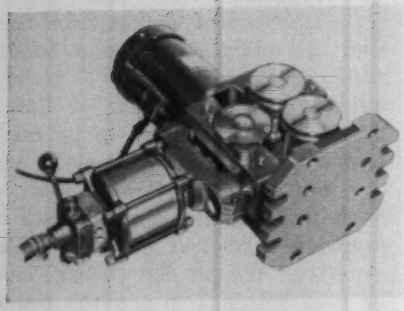
*PATENT PENDING

Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. A5-P

BRUNO-NEW YORK INDUSTRIES CORPORATION

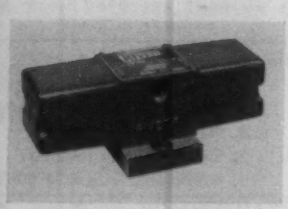
DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT

460 WEST 34th STREET • NEW YORK 1, N. Y.



1.250 finished diameters without using collets or chucks. Fully automatic unit is self-centering and self-adjusting to uniform diameters, lengths, speeds and feeds because the surface speed is constant. Concentricity is maintained through a series of synchronized interlocking rollers driven by a motor. The work piece rotates on its own diameter between the spin rolls while secondary diameters are generated. Unit can be used either as a machine accessory or as a self operating bench unit and is adaptable for rotary machining and grinding operations. Spin roll converts a surface grinder into a centerless external grinder which will accommodate centerless outside diameter work and grind radii on pilots and locators. Adapted to an internal grinder, centering tool will grind bushings and die buttons. Used on lathes to turn, drill bore or chamfer. Spin roll will give jig bore accuracy for concentric work on drill presses. Pressure roll is manual or automatic and accessories available include an air gage, pressure reducer, valve station and quick coupler. Compressed air requirement is 20 lb minimum line pressure. **Pivot Punch & Die Corp.,** 373 Old Niagara Falls Blvd., N. Tonawanda, N. Y.

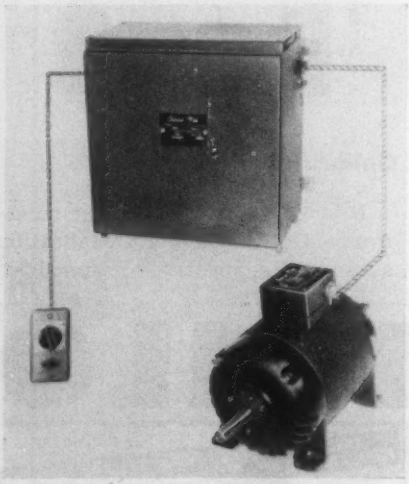
Circle No. **52** *on Reply Card*



Solenoid Pilot Valve

Designed for automatic control of hydraulic circuits, solenoid pilot valve is the subplate mounted type for panel mounting installations. Solenoids operate on 3.6 amp inrush and 0.45 amp holding at 115 v. Wiring box with terminal strip is dust sealed and provides ½-inch conduit connections on each side of the valve. Flow capacity of the valve is rated a 3.6 gpm at 15 ft per second. Seven spool designs are available for any circuit control. Unit is furnished in ¼-inch size in both double and single solenoids. Double solenoid is available in no spring, two position; or spring centered, three position. **Rivett Lathe & Grinder Inc.,** Brighton 35, Boston, Mass.

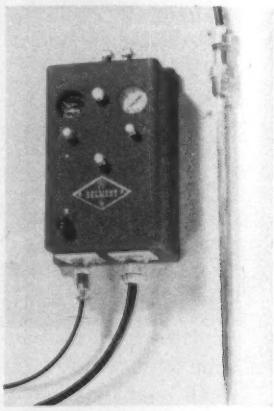
Circle No. **53** *on Reply Card*



Adjustable Speed Drives

New adjustable speed drives use a tachometer feedback signal to hold speed within the desired setting. By remote mounting of the dc tachometer, it is possible to maintain constant linear or peripheral speed of such equipment as rewinders and inspection tables. Two models, ¼ and ½ hp, with either 1800 or 3600 rpm as the base motor speed are available. Both motors supply constant torque over a 30 to 1 speed range. Epoxy resin is used to capsulate resistors and capacitors, within a single plug in assembly. Rectifier cabinet can be either wall or bench mounted and is constructed of aluminum, chromate treated to prevent corrosion and finished in a baked green enamel. Control head uses low voltage circuits that can be installed at a point remote from either the rectifier cabinet or the motor. Control includes a speed adjusting knob as well as a stand-by switch to start or stop the motor. **Servo-Tek Products Co. Inc.,** 1086 Goffle Rd., Hawthorne, N. J.

Circle No. **54** *on Reply Card*

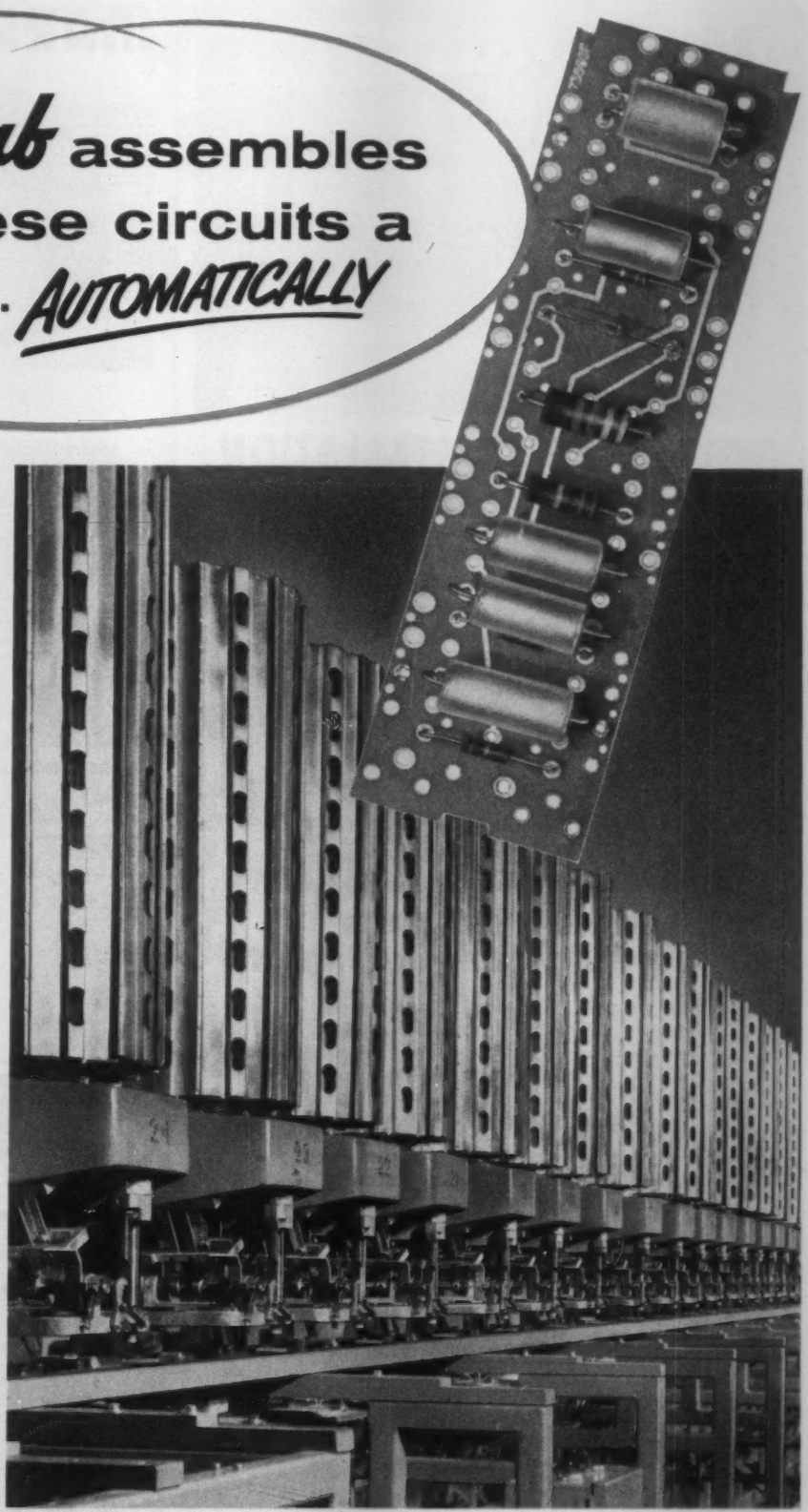


Level Control

Capacitive level sensing with electronic controls terminating in air pressure variations suitable for operating a pneumatic diaphragm control valve are combined in level control devices. Applicable to most nonadhesive chemicals, milk, oils, refrigerants such as ammonia and freons, and all condensed gases over a temperature range of 500 to −425F, control derives a sensing signal from an inert capacitive type probe capable of being operated in applications ranging from high vacuum to pressures of 100,000 psi. Probe is connected by coaxial cable to the electronic circuitry which can be located as far as 1000 ft from the sensing point. Responding to a rising or falling level around the probe, electronic unit actuates an air pilot valve which modulates a 15 psi air supply over a range from 3 to 15 psi. Pneumatic signal can be used directly to actuate small control valves, or where greater volumes of air are necessary, can be fed into auxiliary control equipment. Control unit includes a meter for observation of the output of the electronic control unit, and an air pressure indicating instrument for observation of valve operation. **Thermo Instruments Co.,** 1310 County Rd., Belmont, Calif.

Circle No. **55** *on Reply Card*

Autofab assembles 20 of these circuits a minute... *AUTOMATICALLY*



Here's a machine that can automatically assemble any unit calling for standard electronic components —including tube sockets and I.F. cans—on a printed circuit card. *Autofab* gives you fast, low-cost production of complex assemblies, and it offers many unusual features:

SELF INSPECTING! Besides turning out completed circuits at remarkable speed (1,200 per hour), *Autofab* does its own "inspecting" and refuses to pass any but perfect mountings.

FLEXIBLE! The length of the machine can be varied to fit production needs. And switching from one circuit assembly to another is a fast, easy job. *Autofab* assembles components flat against the boards with leads bent in any direction, or offsets them from the board—or both.

COMPONENTS EASILY HANDLED! *Autofab* feeds components individually from big 8-magazine turrets. Polarized components are kept in alignment automatically.

NO MOUNTING OF CIRCUIT CARDS! *Autofab* positions cards accurately with no lost motion.

EASY TO INSTALL! Standard electric power and compressed air are all you require to power *Autofab*. And its simple mechanical linkages are easy to maintain.

Full details on Autofab *will be gladly sent on request to Dept. G-7, Mechanical Division of General Mills, 1620 Central Avenue, Minneapolis 13, Minnesota.*

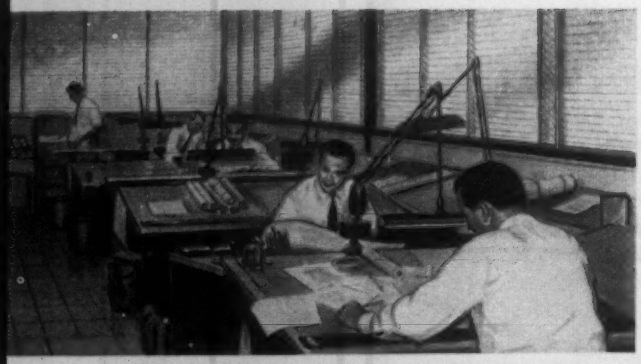
Autofab is a G.M.I. trademark

THIS 24-HEAD *AUTOFAB* MACHINE is now at work for IBM helping to produce printed circuit assemblies for use in air defense computers. Other models are now available for producing circuits used in radios, television sets and other electronic devices.

MECHANICAL DIVISION OF General Mills, Inc.

Job opportunities available for creative engineers. Work closely with outstanding men on interesting projects.

FROM IDEA . . .



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A still better tube construction: Socket, tube and end piece are now all fused into *one* leak-tight unit by the new Marsh "Conoweld" process.

A still better case: New copper clad wrought steel "Marshalloy" case has the corrosion resistance of pure copper; weighs one third as much as cast iron, and is *four times* as strong.

An even finer movement: Further refinements are added to the rugged, corrosion resistant, virtually frictionless stainless steel and monel Mastergauge movement. A typical refinement is the "coined" (extruded) sector gear which contributes extra strength and precision.

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Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alta.

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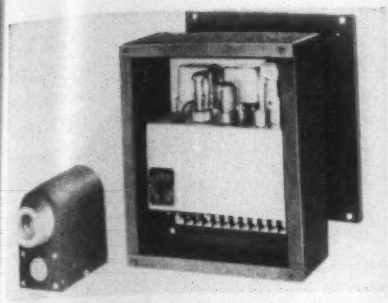

Registration Control

Designed for maintaining accuracy in automatic machine operations on paper, textiles, plastics, tin, steel or other sheet material, registration control operates continuously over both high and low speed ranges. Control responds instantly to the appearance of a mark printed on material moving past at speeds from 15 ft per minute to more than 500 ft per minute. Abrupt change in light intensity caused by the passage of this mark actuates the control relay which triggers speed correction devices, keeping the material synchronized with the machine operation. The scanner supplied with the control consists of a light source, lens system, phototube and amplifier tube mounted in a single housing. Precision lens system is used for both incident and reflected light. It is prefocused to minimize optical alignment at the installation. Operation of registration control is by single-pole, double-throw relay. Contacts are 10 amp, 115 v ac noninductive; 5 amp, 230 v ac noninductive. **Photoswitch Div., Electronics Corp. of America,** 77 Broadway, Cambridge 42, Mass.

Circle No. **56** *on Reply Card*

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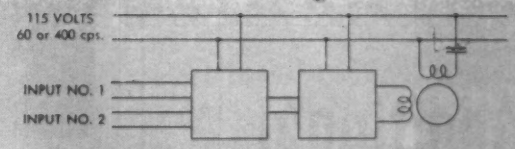

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● **MAGNETIC PRE-AMP + SATURABLE TRANSFORMERS**
Supply: 115 volt 400 cps.
Power output: 3.5, 6, 10, 18 watts
Sensitivity: 1 volt AC
Response Time: .03 sec.
Lowest Cost — Smallest Size
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Supply: 115 volt 400 cps.
Power output: 5, 10, 15, 20 watts
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Highest performance — All magnetic
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Supply: 115 volt 400 or 60 cps.
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Fast response at high gain
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(Advertisement)

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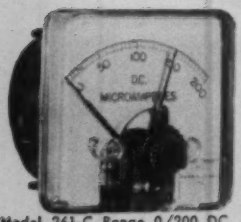
For Sensitive and Accurate Control



Model 261-C Range 0/200 DC Microamperes Price $33.00

RANGES:

0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc. These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully. Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases). Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

Suggested circuits for meter-relays and complete specifications including prices are covered in new 16-page Bulletin G-6, which you can get by writing Assembly Products, Inc., Chesterland 27, Ohio.

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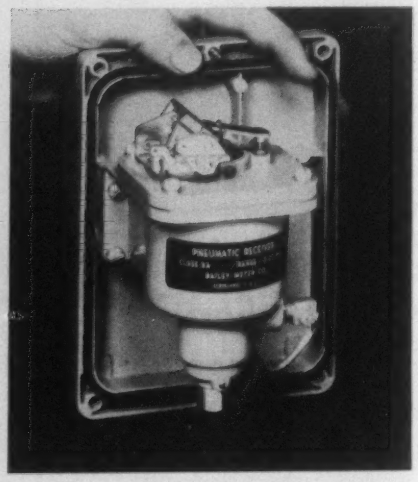
SEE PAGE 104

housings, shaft and ball bearings. Laminations are corrosion resistant, nickel bearing steel. The stator is bonded with housing to prevent null shifts when rotating or clamping synchro in its mount. Materials in unit have similar thermal coefficient of expansion for performance over a wide temperature range. Synchro features 10 minutes maximum deviation spread from electrical zero. It is available with leads or terminals, single or double ended shaft. Excitation is 26 or 115v, high or low impedance. **Kearfott Co.,** 1378 Main Ave., Clifton, N. J.

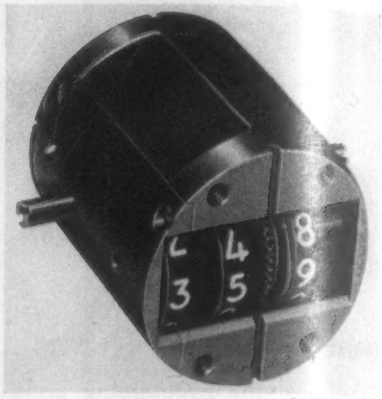
Circle No. **57** *on Reply Card*



Pneumatic Receiver

Multiple recording is standardized through use of plug in pneumatic receiver. Designed for instrument and control systems in power and process plants, unit receives transmitted pneumatic signals of a measured variable and drives a recording pen. Mounting of one to four identical units in company's receiver recorder is made possible by plug in, pin positioned construction and indexed drive arm. Signals may be graphically recorded in any combination from a pneumatic transmitter with 3 to 15 psig or 3 to 27 psig ranges. Receiver is calibrated to less than ±½ per cent of range span and sensitive to signal changes of 0.01 psi. Ambient temperature changes between 30F and 130F are automatically compensated by an isoelastic spring. **Bailey Meter Co.,** 1050 Ivanhoe Rd., Cleveland 10, O.

Circle No. **58** *on Reply Card*



Angle Counter

Designed for use in high speed automatic machinery, fire control devices, radar indicators and positioning of servomechanisms, angle counter features a reduced number of moving parts. Unit indicates angular changes from 0 to 359 degrees and back to 0, in 1-degree divisions. One revolution of the input shaft is equal to one revolution of the unit drum. Counter is useful in clockwise, counterclockwise or reversible applications. Input speed is 500 rpm. Unit is housed in black anodized aluminum; internal parts are treated for corrosion resistance. **Bowmar Instrument Corp.,** 2415 Pennsylvania St., Fort Wayne, Ind.

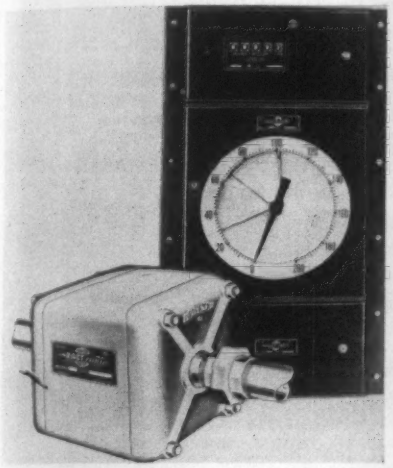
Circle No. **59** *on Reply Card*

Protective Coupling

Designated the Tork-O-Stat, protective coupling is used between any drive shaft and driven shaft to give protection against overloads and sudden jams. When torque rate of Tork-O-Stat is exceeded, internal parts are disengaged and a disconnect results. When the overload or cause of jamming is removed, unit will reengage and normal drive is resumed automatically. Coupling

can be close coupled and requires no lubrication or safety guard. Models have torque ratings of 10, 20, 40 and 60-inch lb, with equivalent hp ratings dependent upon speeds used. Tork-O-Stat is designed for use on packaging equipment, conveyors, screw feeds, mixers and other units vulnerable to jamming and overloading. **Machine Accessories,** Dept. M427, 6 E. Franklin Ave., Minneapolis 4, Minn.

Circle No. **60** *on Reply Card*



Electromagnetic Flow Meter

Known as the Xactronic, new flow meter is designed to measure a variety of conducting liquids. Water and aqueous solutions, acids and other corrosive liquids, slurries, emulsions, opaque liquids, liquids containing solids in suspension, molten salts and liquid metals are metered by this unit. Available in six sizes ranging from ½-inch to 2 inches Xactronic meter will also indicate and record rate of flow and may be used with a pneumatic or electric controller to control the rate of flow. Unit has no moving parts. **Bowser, Inc.,** Fort Wayne, Ind.

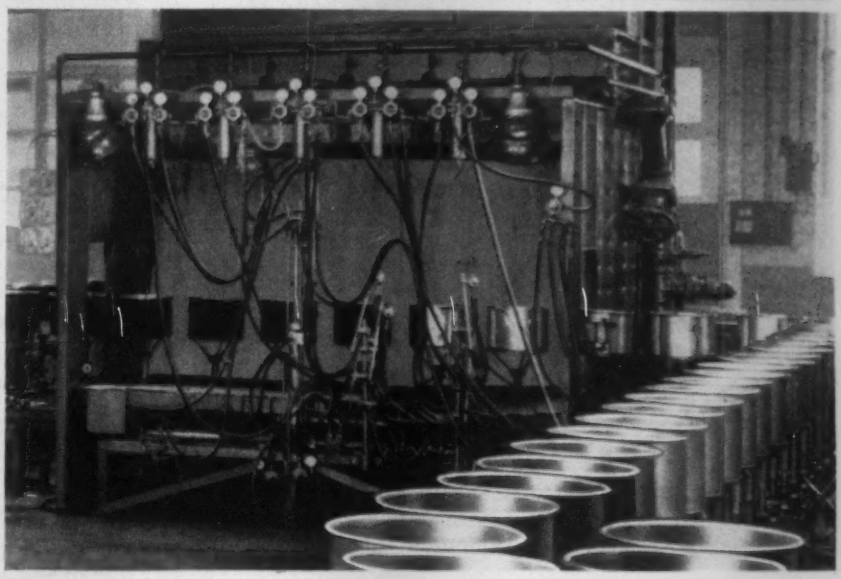
Circle No. **61** *on Reply Card*

High Precision Hydraulic Unit

featuring uniform automatic feeding in drilling and milling, is adaptable to machine tooling jobs and does not require the designing of guide bars and other auxiliary equipment. **Rock River Engineering** Co., Empire Bldg., Rockford, Ill.

Circle No. **62** *on Reply Card*

WHAT'S WHAT in automatic spray painting



Inside gets clear coating... Outside gets black enamel... ...ALL AUTOMATICALLY!

Automatic spray painting is saving millions of dollars for manufacturers in almost every type of industry. The many benefits of automation in this field were recognized early.

In the installation above, pails whirl their way through the spray booth at speeds that defy manual operation. Automatic spray guns apply a beautiful uniform coating of black enamel on the outside and a clear coating on the inside. If a pail is missing, the guns do not operate.

Machines of this kind not only speed up production to unprecedented levels, but also improve the quality of the finish and effect great economies in materials. Automatics can be designed to finish almost any mass-produced product or part. They are the answer to keeping finishing costs down in the face of rising costs.

Free engineering help. Binks engineers work closely with manufacturers in the design and installation of automatic equipment that meets their special requirements. Binks' experience in this field is available to you without obligation. Just contact your nearest Binks Branch Office or write direct to:

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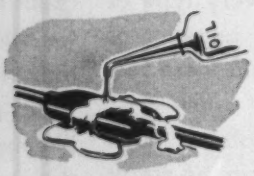
Partners in Production

Joy Electrical Connectors and Automatic Controls

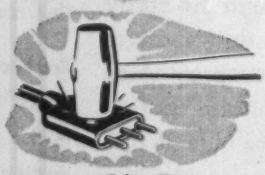
What happens to Automation . . . when electrical connectors fail?

No automatic control system yet devised will keep machines running when an electrical plug or receptacle in their power feeder line or power control circuit *poops out.* That's why JOY's one-piece molded Neoprene connectors deserve your careful consideration. Factory wired and permanently molded to cord or cable, they provide many extra advantages that add up to a long life of dependable service under the most adverse operating conditions. (A few are listed below.) Available in a wide variety of designs with 1 through 16 contacts for 150 to 600 volt applications. **Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.** In Canada: *Joy Manufacturing Co. (Canada) Limited, Galt, Ontario.*

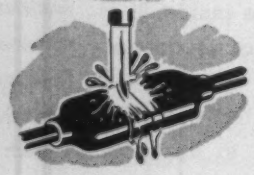
Oil-Sealed . . .
One-piece molded cable connector assembly protects conductors from oil and other external impurities. Face rings protect contacts from similar contamination, when connectors are engaged.



Distortion-Proof . . .
Factory molded as trim one-piece synthetic rubber jacketed units, JOY connectors cannot crack, will not shatter and are practically impossible to knock out of shape.



Moisture-Tight
JOY electrical connectors are absolutely moisture-tight from wiring juncture to face . . . and when connected even their contacts are protectively encased in a resilient housing.



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Electrical Noise in Wire-Wound Potentiometers

BY IRVING J. HOGAN

Research and Development Division
Helipot Corporation

Presented at the 1952 WEST COAST I.R.E. CONVENTION

387

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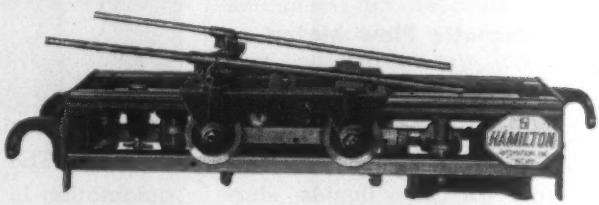

HAMILTON AUTOMATIC AIR SHOVEL

PULL PARTS

Automatically

FROM

PUNCH PRESSES

Hamilton *Inc.*

Automation

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AUTOMATION patents

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Communication

CROSS-TALK CONTROL IN PULSE MULTIPLEX TRANSMISSION SYSTEMS

Degree of cross-talk between adjacent signal channels is indicated by combining auxiliary signals sent over the channels. The magnitude of the product of these pilot signals is indicative of the degree of cross-talk between the channels. Patent 2,681,384 by Gustav Guanella, assigned to Radio Patents Co.

• • •

Components

PRECISION VISE OF THE DOUBLE-ACTING TYPE

Simultaneous action of two fluid pressure elements moves jaws of vise toward or away from each other. Movements of jaws are synchronized by co-operation of racks attached to each jaw and a common gear. Patent 2,679,177 by Franklin G. Gepfert.

FAST STOPPING CIRCUIT FOR HIGH-SPEED SWITCHES

Wiper for a stepping switch is advanced by an electromagnet. An electronic valve connected in shunt with the electromagnet selectively short circuits the electromagnet and prevents stepping of the wiper. Patent 2,682,019 by Imre Molnar, assigned to Automatic Electric Laboratories Inc.

LIMIT SWITCH OPERATING MECHANISM

Longitudinally spaced limit switches are operated at predetermined positions of a rotatable torque tube through action of threaded surfaces and splines advancing or retracting a longitudinally movable element. Patent 2,679,559 by Robert E. Morris and Lyman S. Lee, assigned to Jack & Heintz Inc.

• • •

Computers

REGISTER SUCH AS IS EMPLOYED IN DIGITAL COMPUTING APPARATUS

Means for transferring a number representation from one register to a second register. Each register contains a bank of magnetizable cores with each core corresponding to a related core in the other register. Patent 2,681,181 by Rolf E. Spencer, assigned to Electric & Musical Industries Ltd., Hayes, England.

Controls

APPARATUS FOR RECORDING AND CONTROLLING MACHINE TOOL OPERATION

Electric circuit and timer for timing and indicating tool operation time. Patent 2,679,038 by Ralph E. Cross and Werner H. Jessen, assigned to The Cross Co.

MEANS FOR AND METHOD OF ACCURATELY REGULATING CHRONOMETRIC DEVICES

Uses a magnetic couple to automatically adjust the period of an oscillating chronometric element to compensate for temperature variation. Patent 2,682,744 by Constantin Chilowsky.

• • •

Data Processing

MACHINE FOR SEQUENTIAL FILE MERGING

Combines file cards from two files into a single file of predetermined sequence. Patent 2,681,145 by John T. Ferry, Ralph V. Bennett, Otto E. Kase, and Theodore B. McGirr, assigned to Remington Rand Inc.

CHARACTER SENSING AND ANALYZING SYSTEM

Projected light pattern of character to be read is sensed by a bank of several photoelectric devices selectively controlling contacts completing a separate output circuit for each character read. Patent 2,682,043 by Clyde J. Fitch, assigned to International Business Machines Corp.

• • •

Handling

ROTARY TRANSFER CONVEYOR

High speed rotary transfer conveyor for shifting containers from one line to another line without change in their relative orientation with respect to their direction of movement. Patent 2,681,722 by Paul E. Fischer, Mortimer B. Sturdevant, and Donald F. Thomas, assigned to General Mills Inc.

CONVEYOR ESCAPEMENT MECHANISM

Cam actuated gate removes articles from conveyor but does not retract if an article is not intercepted. Patent 2,676,691 by Hiram E. Temple, assigned to Read Standard Corp.

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Gordon Varney, President
Varney Plastic Scale Models

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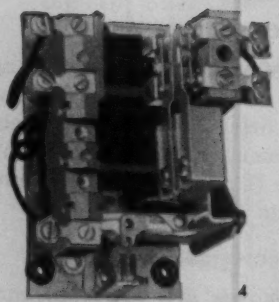
All Electric FLOATLESS
LIQUID LEVEL
CONTROLS



The original—pioneered by B/W in 1933. No floats! No moving parts in liquid. Literature describes relays and starters, automatic starter and relay combinations, multiple pump controls, special controls and panels and many application diagrams.

Controls not affected by pressures, temperatures, acids or caustics. Remote control if desired. Ice free electrodes where necessary.

WRITE FOR CATALOG

B/W CONTROLLER CORPORATION

2190 E. Maple Road, Birmingham, Mich.

MACHINE TOOL MICROFEED

A surge of pressure is applied to the fluid in a lubrication circuit having outlets to sliding surfaces for movable machine tool elements at the same time that the circuit is closed to an electric motor which moves the element. Patent 2,682,203 by Jurg A. Senn, assigned to Kearney & Trecker Corp.

SCREW SLOTTING AND BURR REMOVING MACHINE

Blanks are loaded into radial slots in circular carrier and are caused to rotate under cutters which remove burrs as carrier moves to unloading station. Patent 2,676,343 by Louis Steinfurth, assigned to National Screw & Mfg. Co.

♦ ♦ ♦

Machines

TUBE CUTTING APPARATUS

Cuts tubing into lengths as the tubing continuously moves longitudinally into the apparatus. Patent 2,678,097 by Rea I. Hahn, Bernard E. Frank, and Donald P. Worden, assigned to General Motors Corp.

SHEET TEARING MACHINE

Means for nipping a strip of material and tearing it into sheets of selected lengths. Patent 2,681,109 by Robert L. Sjostrom.

WIRE CUTTING ATTACHMENT FOR BLAST CLEANING OR PEENING MACHINES

Apparatus for receiving wire for blast cleaning or peening, cutting it into particles, and feeding it into a supply bin. Initiating and terminating of operation of the device is responsive to the level in the bin. Patent 2,682,135 by Wiltie I. Gladfelter, assigned to Pangborn Corp.

♦ ♦ ♦

Measuring

COLOR MIXTURE COMPUTING DEVICE

Light beam is passed through a sample of color to be matched. Second light beam is passed through several holders containing ingredient colors to be mixed to obtain desired color. The two light beams are compared and the relative positions of the ingredient holders adjusted to match the light from the sample. Patent 2,682,801 by Hugh R. Davidson and Joseph M. Lambert, assigned to General Aniline & Film Corp.

♦ ♦ ♦

Merchandising

ELECTRICAL COIN REGISTER

Register receives, sorts and checks coins of different denominations, accepts them if sufficient, and activates prime mover to deliver service and give change. Patent 2,677,450 by Christian Gabrielson and John F. Morrison, assigned to Rowe Mfg. Co. Inc.

Packaging

CARTON CONVERTING MACHINE

Completely severed carton blanks having scored folding lines and printed indicia accurately located relative to the scores are produced from a continuously moving web of paperboard. Scrap portions are removed and blanks are accumulated on delivery conveyor belt. Patent 2,682,208 by Charles Z. Monroe and Norton G. Raymond, assigned to Ex-Cell-O Corp.

APPARATUS FOR FEEDING CYLINDRICAL WRAPPERS

Predetermined number and arrangement of cylindrical objects in vertical rows are automatically pushed into containers or other receiving means. Patent 2,682,983 by Donald G. Ashcroft, assigned to Imperial Chemical Industries Ltd., Great Britain.

TABLET COUNTING AND BOTTLING MACHINE

Several containers for tablets and the like are filled from a hopper through individual chutes to each container. An intermittently actuated rotary element having peripheral pockets for individual tablets automatically meters the number of tablets dropped in each container. Patent 2,679,342 by John Fradenburgh, assigned to United States Automatic Box Machinery Co. Inc.

♦ ♦ ♦

Process Design

METHOD AND APPARATUS FOR CONTINUOUSLY ELECTROPLATING HEAVY WIRE AND SIMILAR STRIP MATERIAL

Wire or similar material of sufficient size and hardness is continuously fed through successive plating or other treating baths. The material is formed into a uniform helix and the coils of the helix advanced axially along a rotating suspension member. Patent 2,680,710 by Herbert Kenmore and Walter J. Manson, assigned to Kenmore Metal Corp.

♦ ♦ ♦

Testing

APPARATUS FOR CLASSIFYING ARTICLES BY COLOR

An alternating electric signal is obtained which is related to the chromatic properties of an article being classified, and another electric signal is obtained which is related to the brightness of the article. Patent 2,678,725 by Woodrow R. Jacobson, assigned to General Electric Co.

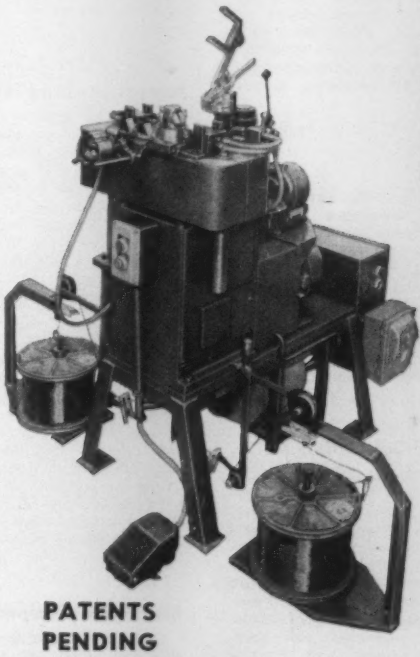
♦ ♦ ♦

Tooling

CHUCK

Headstock spindle has chamfered cylindrical member adjacent to which is mounted a ring of a material having a high degree of elasticity and subject to substantial change in cross-section in response to the application of pressure, which causes the ring to act radially to grip the workpiece and axially to urge the workpiece against the locating means. Patent 2,675,240 by Harold E. Balsiger, assigned to the Landis Tool Co.

with the AUTOMATIC FORT WAYNE



STATOR WINDING MACHINE

WINDS UP TO 150 STATORS PER HOUR

PATENTS PENDING

- Winds 2, 4, 6 and 8-pole stators—all poles on any unit being wound simultaneously.
- Adaptable for index winding series-wound stators or stators for split-phase and multiple speed motors thereby eliminating the interpole connections.
- Standard model winds wire from 19-gauge to 36-gauge at speeds ranging from 300 to 600 turns per minute. Heavy-duty model winds wire from 14-gauge to 18-gauge at speeds ranging from 150 to 350 turns per minute.
- Automatic controls permit selection of any number of turns from 1 to 2000. Cycle is automatically repetitive.
- Takes stacking heights to 3" maximum; diameters to 6" o.d.
- Automatic lead cutoff serves as lead anchor in starting next stator. One operator can handle multiple machines.
- Write for complete data or, if convenient, arrange to call at our plant where a machine is always available for demonstration.

FORT WAYNE TOOL, DIE & ENGINEERING CO.
1027 GOSHEN AVENUE, FORT WAYNE, INDIANA

new CATALOGS AND LITERATURE

Remote Weight Selection

Richardson Scale Co.—Proportioning system which permits remote dialing of individual ingredient weights is described in 28-page bulletin. Brochure discusses 11 installations in such varied operations as remote proportioning of oil shale, cement formulating, blending of feeds, net weighing with automatic tare compensation, liquid latex blending, automatic rubber compounding, differential weighing, glass batching, and maintaining tension on nylon fabric being processed. Forty-seven photographs and engineering drawings illustrate these installations. Design and operating characteristics of automatic proportioning system are also included.

Circle No. 63 on Reply Card

Engineering Service

Pioneer Engineering & Mfg. Co. Inc.—Eight-page brochure outlines experience, facilities and ability of the company's single source engineering service. Services such as product design and development, manufacturing cost studies, and production engineering are discussed in their application to industry's engineering requirements. Brochure also includes list of products involving industrial, mechanical and electromechanical engineering completed by the company in the last 25 years.

Circle No. 64 on Reply Card

Pneumatic Indicating Controller

Foxboro Co.—New 12-page brochure discusses pneumatic indicating controller for control of process variables such as temperature, pressure, liquid level and humidity. Proportioning mechanism is diagrammed and explained and typical applications are shown. Separate sections are devoted to temperature and pressure measuring systems, with information on the filled thermal systems available, temperature bulbs and accessories, new pressure elements, pressure seals and control valves.

Circle No. 65 on Reply Card

Logical Building Blocks

Computer Control Co. Inc.—Four-page brochure discusses logical building blocks and gating packages. Among uses of these instruments are those in high speed digital computer installations, arithmetic, programming and control systems, classroom demonstration, data conversion and data handling systems, logical selection units for operations research and business computers for accounting and production control. Brochure explains components of these packages and gives data and charts illustrating their operation.

Circle No. 66 on Reply Card

Side Indicator Panel Meters

International Instruments Inc.—Engineering data sheet gives information on standard ranges and approximate resistances, special variations, specifications, physical dimensions and mountings of new series of side indicator panel meters. Units are designed for use with electronic control panels. They can also be used as null indicators in tuning circuits or as position indicators. Illustrations show vertical and horizontal mountings of panel meters. Units can be installed on magnetic panels up to ⅛-inch thick without recalibration.

Circle No. 67 on Reply Card

Machines and Machine Tools

Baker Brothers Inc.—Ten-page brochure discusses development of company over 75-year period. Photographs of engineering, planer, boring machine, jig boring, spacer, grinding, lathe, inspection and assembly departments are included. Along with photographs is included discussion of applications of equipment made in each department. Equipment made by company includes drilling, boring, tapping, keyseating and contour grinding machines.

Circle No. 68 on Reply Card

Telephone Type Stepping Switches

Automatic Electric Sales Corp.—Suitability of telephone type stepping switches in computer functions is discussed in new bulletin. Use of rotary stepping switch in a Berkely digital recorder is cited as an example. Telephone type relay converts into printed form electronic count information which would otherwise have to be obtained visually. Unit is said to eliminate factor of human error, making possible an increase of several hundred per cent in cycling rates.

Circle No. 69 on Reply Card

Motor Catalog

Holtzer-Cabot Motor Div., National Pneumatic Co. Inc.—New catalog discusses line of motors, motor generator sets and related products. Booklet includes complete range of frame sizes from dc servomotors of 1⅝-inch diameter to power motors of 7-inch diameter. Motors with integral gear reduction are included in smaller frame sizes of both synchronous and nonsynchronous types.

Circle No. 70 on Reply Card

Electronic Equipment

Chatham Electronics — Four-page brochure discusses lines of electronic equipment for government, industrial, communication and research applications. Several models of rectifiers, thyratrons, hydrogen thyratrons, power triodes and voltage regulator tubes are illustrated. Electrical data and applications of equipment illustrated in brochure are included.

Circle No. 71 on Reply Card

Small Parts Handling Equipment

Chas. Wm. Doepke Mfg. Co. Inc.—Eight-page catalog discusses products in line of small parts handling equipment. Brochure illustrates applications of nesting-stacking boxes and baskets, rollover hoppers, hopper rack assemblies and shelf racks. Photographs of the equipment, along with their specifications are included. Units can be used singly or in combinations, and are said to eliminate rehandling and to simplify parts control.

Circle No. 72 on Reply Card

Bowl and Barrel Feeders

Detroit Power Screwdriver Co.—Two brochures discuss applications of bowl and barrel feeding devices. Barrel feeder selects, orients and feeds parts in a uniform position for primary and secondary machining operations. Bowl feeder selects and handles parts not adaptable to other types of feeding devices and does not require churning of parts. Photographs illustrate barrel form feeding and counting cap screws, and selecting, feeding and assembling metal tips to ignition wires, cast bowls feeding small closures and faucet washers; fabricated bowls feeding glass tubes and rubber grommets are also pictured. Specifications and charts illustrating feeding cycle are included.

Circle No. 73 on Reply Card

Hydraulic Cylinders

Miller Fluid Power Co.—Eight-page brochure contains information on line of heavy duty, 2000 psi high pressure hydraulic cylinders in 1½ through 12-inch bores, up to 22-ft strokes and 19 mounting styles. Brochure includes design, engineering, construction, mounting, dimensional and operation data. Models covered include the interchangeable type pivot mounting and trunnion mounting cylinders and the precision seal cylinder. Information on high temperature operation is also given.

Circle No. 74 on Reply Card

Packaged Conveyor End Assemblies

Sandvik Steel Belt Conveyors, Div., Sandvik Steel Inc.—New brochure discusses packaged terminal end assemblies for steel belt conveyors. Brochure covers both tension end and drive end component assemblies. Four types of tension end assemblies—spring, counterweight, pivoting weight and take up bearing—are illustrated and described in detail. Proper application for each type is given. Brochure explains how the tensioning device, pulley with shaft and bearings, safety scraper and pulley cleaner are mounted in a supporting steel frame to form a complete packaged unit. Two drive end assemblies are covered, with line drawings and text explaining how the drive can be positioned either between the conveyor belt strands or adjacent to the conveyor. Included are lists of the elements supplied with each end assembly as well as schematic drawings illustrating various conveyor components.

Circle No. 75 on Reply Card

Angle Compressor

Pennsylvania Pump & Compressor Co. — Eight-page bulletin covers two-stage, water cooled, angle type compressor. Two large schematic drawings illustrate 24 components of machine, explaining function of each. Distance pieces, bearing mounting, conecting rods, crosshead, crank shaft, pistons and rods, valves, intercooler and intercooler drain are covered. Also discussed is the lubrication, oil filter, oil pressure failure switch and control of the machine. Photographs and specifications of the angle compressor are included.

Circle No. 76 on Reply Card

Brazing and Soldering Machine

Youngberg Bros.—Four-page brochure discusses multiflame brazers which can be used for brazing, soft soldering, hardening, annealing and tempering. Machine operates on principle of heat generated by burning gas and air under pressure. Photographs of brazing machine illustrate its pushbutton control and adaptability to rotary design. With the addition of feeds or fixtures, multiflame brazers can be fully automated.

Circle No. 77 on Reply Card

Punched Card Machines

Remington Rand Inc.—Six-page brochure illustrates complete line of punched card ma-

Here's how you can tell

THE KEYSTONE 3-POSITION INDICATOR gives you information on plant operating conditions *where you want it:* right in your office! Without moving from your desk, you are constantly "within eyesight" of your whole plant.

These are indicators you can rely on. They were developed and are still used in the aircraft industry to report critical operating conditions to the pilot. They will give you a *yes-no, on-off, high-low* answer at a glance, swiftly, conveniently, reliably.

Facts: Readily installed. Hermetically sealed, impervious to dust and moisture. Easily read. Conforms to Government specifications. Adaptable to both AC and DC over wide range. Send coupon for complete information.

KEYSTONE WATCH CASE & INSTRUMENT DIVISION

A DIVISION OF **HKP** H. K. PORTER COMPANY, INC.

THE RIVERSIDE METAL COMPANY, RIVERSIDE, N. J.

SEND COUPON TODAY FOR COMPLETE INFORMATION

KEYSTONE WATCH CASE & INSTRUMENT DIVISION
Dept. 1
The Riverside Metal Company, Riverside, N. J.
Gentlemen:

Please send me complete information and specifications of the KEYSTONE 3-POSITION INDICATOR. I am interested in applying it in_____
(State use you have in mind)

YOUR NAME_____

FIRM NAME_____

ADDRESS_____

CITY_____ STATE_____

NEW CATALOGS AND LITERATURE

chines showing their uses in the preparation of management records for billing, receivables, sales, payroll and production. Illustration and a short description is given for each of punched card machines. Among these are punches, reproducers, computers, arrangers and printers. Brochure is made up in chart reference form.

Circle No. 78 on Reply Card

Machinery Mounts

Barry Controls Inc.—Eight-page brochure describes leveling mounts and spring isolators. Mobile mounting is said to produce flexible production layouts, less downtime for maintenance and reduced installation costs. Photographs illustrate machinery mounts in application. Also included are specifications charts, sketches showing construction of mounts, selector charts and summary of types of machinery mounts which have been engineered for applications on various machines.

Circle No. 79 on Reply Card

Power Supplies

Lambda Electronics Corp.—Catalog of regulated and unregulated power supplies for industrial and laboratory use contains specifications for 35 models. Twenty-five page brochure includes photographs and list of special features of models. Additional pictures illustrate power supplies in actual applications. A check list of company power supplies and ordering information complete the brochure.

Circle No. 80 on Reply Card

Sheet Metal Products

Bud Radio Corp.—Comprehensive 52-page catalog discusses fabricated sheet metal products such as panels, housings, racks, and cabinets, used in the electrical and electronic industries. Specifications, photographs, and operational data on television antenna mounts, condensers, coils, plugs and jacks, insulators, hardware, terminal strips and numerous other components are included.

Circle No. 81 on Reply Card

Single Turn Potentiometer

Helipot Corp.—Data sheet describes single turn, continuous rotation potentiometers for bushing mounting. Units were developed for use in aircraft servosystems. Outline drawing indicates specifications of Series G potentiometer, and charts give characteristics of standard linear coils and models. Cutaway photograph illustrates components of potentiometer.

Circle No. 82 on Reply Card

Sintered Metal Filters

Permanent Filter Corp.—Sixteen-page brochure discusses modern filtration and the advantages of using sintered metal elements in filters. Photographs illustrate head selection and construction, and charts and graphs indicate specifications and operating characteristics of filters. Light duty bulk handling and industrial filters are covered, along with aircraft and missile hydraulic line type filters.

Circle No. 83 on Reply Card

Case History Bulletin

Eriez Mfg. Co. — New 24-page brochure, "Magnetic Ideas from Eriez" discusses case histories, with actual photographs of installations, explaining how various companies are using permanent, nonelectric magnets to prevent iron contamination in their production, to protect their machinery from damage by tramp iron or prevent fires. Magnetic equipment covered in illustrations are plate magnets, magnetic grates, magnetic pulleys, ferrous cleaners and magnetic sweepers. Listed under main industry headings such as chemicals, drugs and medicines, glass and ceramics, metal working, milling, food and textiles are approximately 100 uses for permanent magnets.

Circle No. 84 on Reply Card

New Valve Principle

Barksdale Valves—Comic strip illustrations are used to explain "Shear-Seal" principle of valves. Cutaway views of new valves show rotor, shaft, ball bearing and thrust washer. Valve features leakproof service because rotor and valve are both lapped optically flat, and held in initial contact by a spring, preventing liquid from escaping. Valve is said to have longer service life, since rotor and valve seal tighter together each time they lap themselves with use. Inside back cover of 10-page brochure contains cut out models of the valve and a cross-section to further illustrate shear-seal principle.

Circle No. 85 on Reply Card

Liquid Alum Feeding

Builders-Providence Inc. & Omega Machine Co.—Data sheet discusses liquid alum feeding in the paper industry. Function of Venturi meter and liquid feeder which continuously meter and treat paper mill water supply is explained. Flow sheet illustrates operation. Also included are sections on the description, advantages and similar applications of these units in combination or singly.

Circle No. 86 on Reply Card

● This compact unit has a conveyor frame only 1¾" wide yet has capacity for parts from ¼" to 1½" in diameter. Standard Model is 62½" long. Powered by a ¼ H.P. 3-phase motor. It also features easier speed adjustment. Other sizes are available to meet your specifications.

In addition to Transfer Conveyors FEEDALL has a varied line of Automatic Feeders with Blade, Hopper, Rotary or Vibratory Feeds, for handling a wide variety of small parts such as bolts, screws, valves, bushings, piston pins, etc., etc.

Why not let our engineers give you the benefit of their experience in solving your feeder problems. Write today.

FEEDALL
INCORPORATED
WILLOUGHBY, OHIO, U. S. A.

Furnace and Oven Control

Bristol Co.—New edition of the price list and specification catalog for furnace and oven control instruments and accessories contains over 100 illustrations. Detailed specifications and engineering data necessary for choosing the proper pyrometers and control equipment for heat treating, metal processing or other industrial heating applications are included. Bulletin describes and illustrates components required in industrial heating systems, including electric control relays, motor operators and controllers, and electric and air operated control valves. Accessory equipment is also covered.

Circle No. 87 on Reply Card

Magnetic Clutches and Drives

Electronic Mfg. Engineers Co.—Eight-page brochure discusses line of magnetic clutches and drives. Nine possible clutch combinations are listed, along with ordering information, price list, specifications, and special features. Units have applications in speed changers, differential drives, computers, multiple servo-drives and multiple remote positioning devices. Single and multiturn models of clutches; and gear, cable and direct-in-line drives are covered.

Circle No. 88 on Reply Card

Synchronous Motors

Electric Indicator Co. Inc.—Twenty-four page brochure describes more than 125 hysteresis and salient pole induction synchronous instrument type motors. Performance curves and characteristics are given for single, dual, three and five-speed hysteresis models for operation at frequencies from 30 to 400 cycles. Data is also included for polarized and stabilized units, as well as for subfractional motor-generator sets which combine ac synchronous motors with ac permanent magnet generators.

Circle No. 89 on Reply Card

Industrial Television Equipment

Radio Corp. of America—Features, applications and construction details of industrial television equipment are included in four-page brochure. Industrial television equipment makes possible viewing at a distance a picture of a scene or operation where direct observation is too dangerous, too inaccessible, too inconvenient or too expensive. Equipment has found applications in commerce and banking, industrial control and testing, medical applications, military operations, security and law enforcement and traffic control. Photographs, specifications and installation information are also given in the brochure.

Circle No. 90 on Reply Card

Bar Feeding Equipment

Lipe-Rollway Corp.—Air operated attachment which automatically feeds an eight-hour supply of bars, rods or tubing to any machine tool equipped with a stop to establish feed length, is the subject of a 22-page brochure. Machine is applicable to single spindle screw machines, turret lathes, centerless grinders, abrasive wheel cutoffs, punch presses, cold headers and die machines. Brochure includes photographs of machine in operation, a chart indicating net gains in production through use of this machine, and excerpts of letters from users of the bar feed.

Circle No. 91 on Reply Card

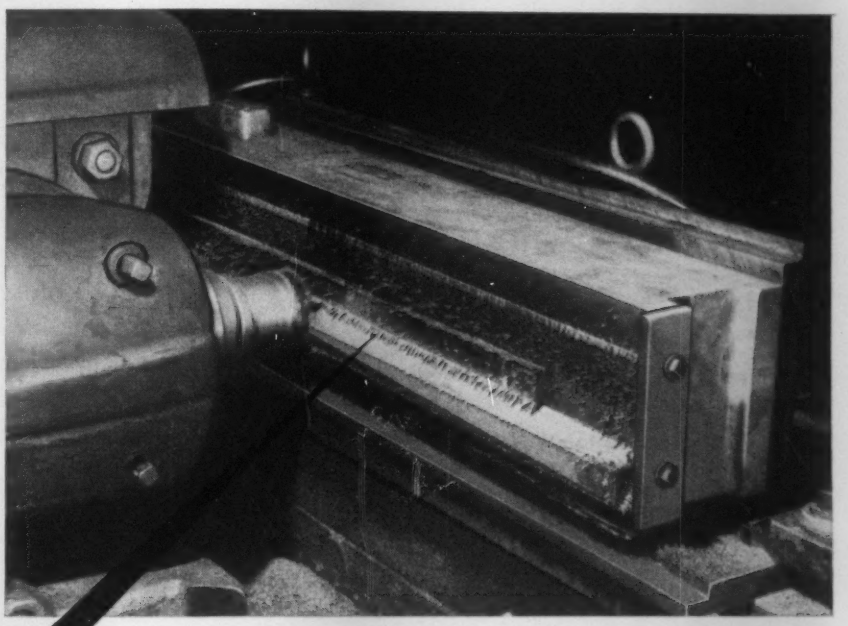
Rotary Converter

Sangamo Generators Inc.—Six-page brochure discusses line of rotary converters for conversion from dc to ac. Six models are illustrated, with and without filters. Detailed specifications of models are given, along with dimensions and applications. Units have double wound armature and are available in drip proof and ventilated models. Photographs of company dynamotors, motor generators, special dc motors and generators are also given.

Circle No. 92 on Reply Card

Variable Speed Pulleys

Equipment Engineering Co.—Eight-page brochure describes variable speed pulleys and systems. Included in the brochure are graphs,



Magna-Lock Magnetic Chuck
at Turchan Follower Machine Company

REDUCES SETUP TIME 66.6%

THE JOB: Milling hard cast iron gibs, 1⅜" maximum width, variable lengths, 60° compound angle, .250" taper per foot. Roughing cut: 1⅜" max. width, 0.200" depth. Finishing cut: 1⅜" max. width, 0.050" depth. Spindle speed: 385 RPM. Cutter: 8-flute carbide tip 3" dia. Table speed: 15 IPM-20 IPM. Stock removal: Approximately 4 cu. in. per min. Fixture: mechanical.

THE PROBLEM:

1. Fixture setup time and handling was 60 minutes plus time required to lay out, drill and tap holes in the gibs to coincide precisely with the bolts of the fixture. Spacing varied between 9" and 10" at several intermediate increments.
2. The holes were not functional parts of the gibs, being used only to hold the gibs while being milled.
3. Because of the several milling operations, the gib had to be removed each time and re-bolted to the fixture.

THE SOLUTION: A Hanchett MAGNA-LOCK Magnetic Rectangular CHUCK positioned on a sine bar, the milling machine cutter spindle being swiveled to the corresponding angles.

THE RESULT:

1. FIXTURE SETUP AND HANDLING TIME — 20 MINUTES.
2. Lay out, drilling and tapping operations eliminated.
3. Time required to re-bolt gibs on fixture for each operation eliminated.

You, too, can increase your machines' productivity with Hanchett Magna-Lock Magnetic Chucks and Devices. Take advantage of Magna-Lock's experience and engineering know-how — at your service to help you solve your holding problems. Magna-Lock is the only *exclusive* manufacturer of magnetic chucks and devices. WRITE TODAY, Dept. A-55.

Request Magna-Lock as original equipment on your new machines.

Hanchett **MAGNA-LOCK CORPORATION**

Magnetic Chucks and Devices

BIG RAPIDS, MICHIGAN, U. S. A.

ELECTRICAL ENGINEERS
PHYSICISTS
TECHNICAL WRITERS
CONTRACT ADMINISTRATORS
MATHEMATICIANS

IF YOU HAVE a background in electronics, there is a good job waiting for you in the fastest growing firm in America's fastest growing technological field.

At Remington Rand's ERA Division you can participate in the further development of the famous ERA 1102 Computer, the new Univac File Computer, and special new developments in data-handling, communications, and instrumentation.

Pay, special benefits, and opportunities for advancement are excellent.

Send a resume
of your training and experience to:

REMINGTON RAND Inc.
ENGINEERING RESEARCH ASSOCIATES DIVISION
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the RCA COMPUTER ENGINEER

RCA's continuous electronic research and development provide immediate openings in its Digital Computer Activity for EE's, ME's, Physicists and Mathematicians. Junior and Senior openings in all fields.

These positions will offer a challenge to your skill and creative ability. Openings are in the Greater Philadelphia area.

There are many opportunities in:

- *PROGRAMMING*
- *INPUT-OUTPUT DEVICES*
- *VIDEO PULSE TECHNIQUES*
- *MAGNETIC RECORDING*
- *HIGH SPEED MEMORY*
- *FEED BACK AMPLIFIERS*
- *CODING AND DECODING*
- *RELAY CONTROL*

Send a complete resume of your education and experience to:

Mr. John R. Weld, Employment Manager
Dept. B-9E, Radio Corporation of America
Camden 2, New Jersey

RADIO CORPORATION OF AMERICA

NEW CATALOGS

diagrams, cutaway views and photographs of the variable speed pulley in application. Specifications and list prices of the pulley are given, along with data on three available bases. One page is devoted to a discussion of the Hi-Lo system, supplemented by complete speed range tables.

Circle No. 93 on Reply Card

Controllers and Indicators

West Instrument Corp.—Comprehensive 62-page catalog describes company line of indicating and controlling equipment. Complete catalog includes information on off-on controllers, proportioning controllers, switch indicators and switches, temperature indicators and portable indicators and controllers. Section on pyrometer accessories gives thorough description of thermocouples and related accessories available. Catalog is tabbed for easy reference to desired section, and includes photographs, diagrams and specifications data on instruments discussed.

Circle No. 94 on Reply Card

Automatic Welding Machines

Expert Welding Machine Co.—Comprehensive 54-page catalog describes company line of welding machines, automation machines and machine tools. Forty-six types of automatic welders for submerged arc, resistance and Heliarc welding operations are illustrated. The automation machine section of the catalog includes photographs and information on automatic assembly and automatic nut torquing machines. Among special machine tools are horizontal and vertical boring machines, drilling and tapping machines.

Circle No. 95 on Reply Card

Machine Tools

Snyder Tool & Engineering Co.—Twelve-page catalog describes automation machines, machine tools and mill balancing machines. Transfer machines, center column machines and machines for metalworking operations such as drilling, reaming, tapping, boring, turning, milling and mill balancing are discussed. Catalog includes photographs of machines and machine tools in application and specifications of equipment.

Circle No. 96 on Reply Card

Ac Motor Booklet

Reliance Electric & Engineering Co.—Twelve-page booklet contains 100 facts about line of ac motors. Description of protected and enclosed motors is given, along with data on fan cooled, corrosion proof and explosion proof designs. Brochure, called "Check the Facts," includes sketches and photographs of ac motors.

Circle No. 97 on Reply Card

Relay Catalog

Guardian Electric Mfg. Co.—Comprehensive 72-page catalog describes company line of relays. Physical and electrical characteristics, operating data and suggested applications for each relay discussed are given. Ac and dc relays include sensitive, heavy duty, versatile industrial, midget, telephone, general purpose, snap switch and interchangeable aircraft relays. Illustrations and dimensional drawings, along with definitions of engineering and electrical terms, complete the catalog.

Circle No. 98 on Reply Card

Buying and Renting Machine Tools

Gisholt Machine Co.—Purchase and rental of machine tools is the subject of an eight-page brochure. One section is devoted to a discussion of depreciation and the new tax provisions regarding it. Also covered are company payment and rental plans for machine tools. Replacement of machine tools is discussed, and the Machinery and Allied Products Institute formula for replacement is included. Photographs of ram type turret lathes, superfinishers and balancing machines complete the brochure.

Circle No. 99 on Reply Card

AUTOMATION abstracts

COMPUTER IN INDUSTRY

By W. W. SMITH
General Electric Co.
Louisville, Ky.

ELECTRONIC COMPUTERS are destined to be recognized as the most powerful management tool yet developed. When part of an intelligently designed system, computers offer the new and exciting capacity to provide management with information never previously available—information which management requires to make sound decisions. It follows that to design and apply such systems, methods personnel must understand not only those factors influencing management decisions but also the decisions themselves. To exploit fully the potential of computers in application to business problems, related methods activity realistically must not be confined simply to improving or developing systems whose parameters are narrowly and rigidly defined. All computer applications should be considered in an atmosphere of critical, creative thinking with a minimum of regimentation.

With electronic computers and the electronic data processing concept providing the impetus, methods work is rapidly becoming that of a profession whose objectives are undergoing a transition from a responsibility to save money to a broader and more challenging responsibility to make as well as to save money.

We have all heard many times that the Second Industrial Revolution is here or has been here for many years. Such comments have usually been the result of excitement in relation to some new efficiency in manufacturing operations or of some further degree of factory automation. That progress has been made in the efficiency of manufacturing operations cannot be disputed. But I think that most of us might question that the Second Industrial Revolution has firmly established itself. Until we can actually control and take full advantage of our progress in automating the factory, we cannot say that we have achieved this second revolution.

For example, does manufacturing management actually know the true capacity of its plant; can it, when necessary, literally turn production on a dime? Is accurate and timely information available to the marketing executive so that he can determine as well as he would like the sales activity of every product at every point of the distribution pipeline? Is he certain of control over the relationship between sales and finished goods inventory? Do financial reports tell us what they are intended to, and fast enough to permit effective action? Electronic computers are likely to exhibit their most important contributions in application to systems which will provide solutions to such problems as these. And when we have achieved these solutions, we may have reached the point when it will be time to talk of the Second Industrial Revolution.

Initial Applications

At Appliance Park, the new home of General Electric Major Appliance Div., we have completed the first business installation of a large-scale computer system. Our decision to acquire a Univac system was based primarily upon an analysis of the direct economic aspects of applying computers to certain basic business operations. We determined that the installation could be economically justified by four initial applications in the areas of payroll, material scheduling and inventory control, order servicing and billing, and general and cost accounting. It was recognized, however, that the greatest value would come from applications beyond the initial four. Our business, which is the manufacture of large household appliances—refrigerators, electric ranges, automatic clothes washers and dryers, etc.—is a dynamic one and it is rapidly expanding. It is an exciting, glamorous business but it is also subject to extreme competition and to every vicissitude of the American consumer. To compete successfully, we must have the ability and flexibility to anticipate, cope with, and even make a competitive advantage of variations in consumer demand. We expect that the greatest value of our computer will be its capacity to help us strengthen this ability.

I'd like to describe briefly how we are applying Univac in each of the four initial areas just mentioned.

Our first project was the development of a complete and integrated payroll system, on which I should like to comment only very briefly. In the payroll application, the computer will extend the mass of time cards and piecework tickets, sort by employee number, compute gross pay, compute and make deductions to arrive at net pay, and finally reshuffle all calculated

detail to compute labor distribution and labor variances. The computer system will make all calculations; print checks, check stubs, payroll register in detail, payroll journal in detail, and all necessary accounting entries. Our payroll system is now a working fact and will soon be preparing the payroll for all Appliance Park employees.

In contrast to the payroll application, which will be using essentially the same input data and will provide essentially the same output as our present semimechanical systems, the material scheduling and inventory control application is expected to develop new information of great value.

Briefly, the function of the computer in this application will be to digest the mass of source documents affecting inventory status and to issue timely reports based upon daily analyses of conditions. The computer will explode any proposed production schedule and will automatically determine the material requirements for every item for any selected period of time. For the current production schedule, it will prepare shortage reports by item and overage reports by item, enabling management to anticipate critical situations in sufficient time to provide for effective action. It will maintain perpetual records of inventory and activity by item as affected by production, material shipping schedules, purchase orders, receiving reports, withdrawals and returns to stock, etc.

Perhaps the most important result of this application will be that management should be able to analyze the effect of a proposed production schedule on the inventory situation. We have not been able to do this effectively before. For example, if the decision is made to increase production of appliances from 1000 to 2000 per day, Univac, within a matter of hours, will be able to show the effect on very item of inventory. It may say that, at the proposed schedule, we will be out of item *A* next Friday morning or tell us that we must order item *B* by this afternoon if we expect to have it in the plant on time. To do the same job on a manual basis as one part of total manufacturing planning often requires up to three weeks or longer. In the future, it is also possible that Univac will (1) write purchase orders telling us what to buy, in what quantities, and from what supplier, and (2) write arrival schedules telling our vendors what date certain materials must arrive at Appliance Park.

Order service and billing application involves the mechanization of routine clerical effort. It is planned that the computer will process orders received from our distributors and will prepare order acknowledgement letters, shipping release schedules, bills of lading,

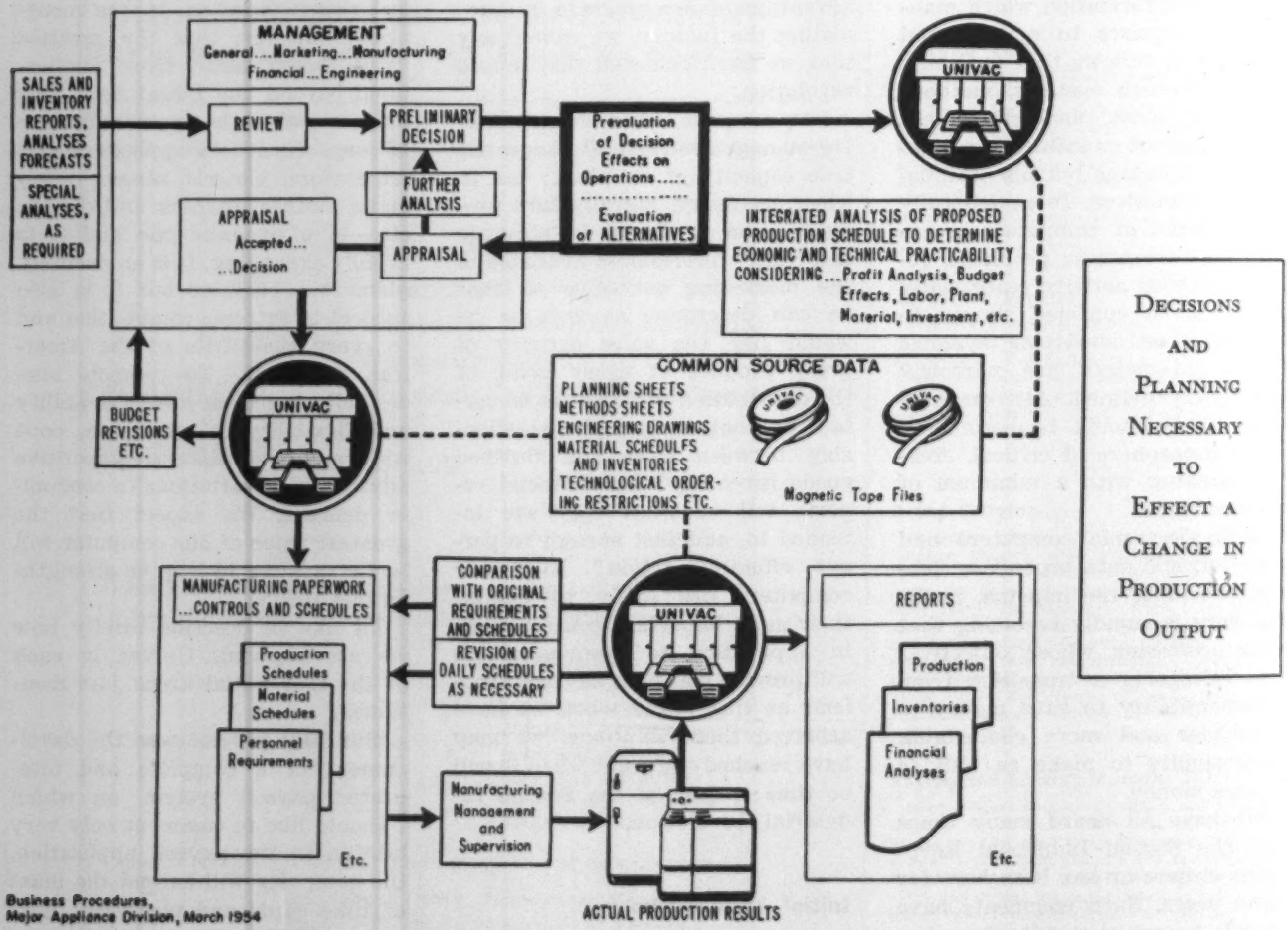


Fig. 1—Presentation to the management group of sales and inventory information is indicated in the upper left hand corner of the chart through application of Univac in the areas of marketing and distribution. After a preliminary decision is made to increase production, the computer can statistically determine the technical and economic practicability of the contemplated production schedule from the standpoint of labor, inventories and physical equipment

invoices, and sales and cost of sales journal entries. One of the particularly important contributions may be the automatic preparation of consolidated car-loading schedules for shipments directly to our dealers.

General and cost accounting application will utilize the output of the other applications, together with other journal entries, as its input for the preparation of financial reports and statements. Most important, however, this application is the first step toward an integrated system of management control.

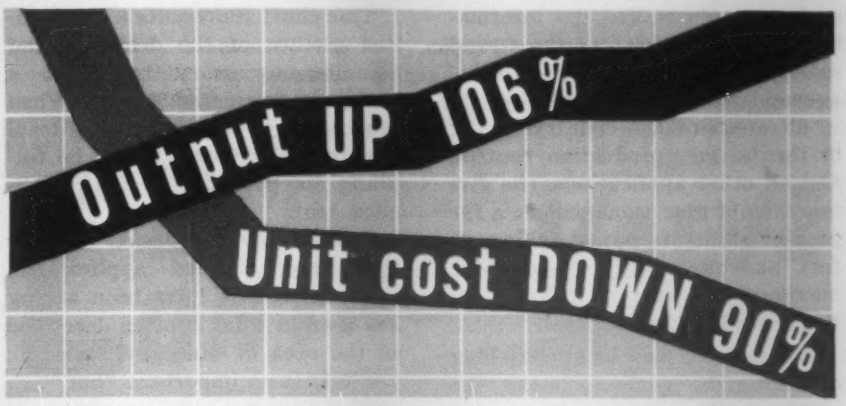
Co-ordinated Plan

We are also planning other activities for Univac. In contrast with the initial applications, however, the element of new information for management guidance is quite marked. These other activities include factory machine-loading schedules, assembly line balancing, budgets and marketing.

I'd like to interject this comment. I want to emphasize that my discussion of future plans and future computer applications is largely an expression of our thinking. We have made limited progress in certain areas. Our progress has been sufficient to encourage us in our investigations. At this point in our planning, however, it is impossible to determine to what degree any or all phases of contemplated applications will justify use of a computer.

All of the applications we are working on or are considering will be co-ordinated on a master plan which will permit maximum use of common input and output data. In addition to its data processing function, we expect that the computer will become a very effective communication device. By using common source data, it will eliminate communications problems before they exist. By its ability to make integrated analyses and reports which reflect the requirements and results of all management functions, it will minimize the problems of communication among all functions of a department.

Our long-range objective is the development of an integrated management control system. Such a



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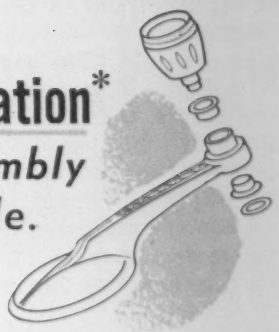

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system would utilize the information from market analyses and sales projections to report to management the pulse of retail trade in all areas of the country. Tying in the budget, production control, and all other applications, the system should give management a far greater ability to adjust selling effort and factory effort to make maximum use of productive facilities placed at its disposal.

It means we may be approaching our ultimate goal—to make the right appliance and to have it at the right place, in the right quantity, at the right time, and at the least expense. If we can do this to any degree, the effect upon the profitability of our operations, upon our ability to compete effectively, will be staggering.

One concept of part of an integrated system may be illustrated by the accompanying diagram, *Fig.* 1. This chart represents a skeletonized picture of the decisions and planning necessary to effect a change in production output. When the Univac becomes part of a total system such as this, it will be fulfilling its potential as a management tool.

Beyond my discussion of our first four planned applications, much of what I have been saying has been in what is often described as the area of blue sky. But . . . and this is an important "but" . . . we feel that we have already made enough progress in certain of our investigations and have seen sufficient evidence to be convinced that many of these things may soon be accomplished. We feel that the greatest contribution that our computer has made to date has been its stimulus to our thinking.

I should like to conclude by strongly emphasizing one point. The Univac or any other computer, large or small, at best is only a very powerful tool. Many of the things I have discussed here will be realized without the use of a computer. Many of them, on the other hand, could not be achieved without a computer. None of them will be realized without the sound thinking and hard work of people. Methods personnel, covering the experience range from forms design to operations research, are logically suited to play the starring role. The implications, opportunity, and challenge involved in changing these ideas into practical, working systems present what I like to consider as the true impact of computers on methods.

From a paper entitled, "Impact of the Computer on Methods" presented at the Office Management Conference of AMA in New York, Oct. 1954.

ELECTRONIC WEIGHING AUTOMATION

By V. C. KENNEDY
Streeter-Amet Co.
Chicago, Ill.

ELECTRONIC weighing techniques have been put to an ever increasing number of uses. Although components and techniques of electronic weighing have already undergone much advancement and are now in successful use in numerous installations, electronic weighing as a whole may still be regarded as being in its infancy.

Fundamentally, the electronic scale comprises three basic elements. They are, the load cells, the servosystem and the data presentation device. During operation, the weight to be measured is placed on load cells consisting of small electrical units sensitive to mechanical force which produces an output voltage proportional to the applied weight. This proportional voltage is fed into the servosystem which interprets the magnitude of the voltage by automatically adjusting a balancing potentiometer to an equivalent position. At the same time that the servosystem positions the potentiometer, it also positions the data presentation device—digit wheels in a printer, pointer of a dial, etc. —to a corresponding position. The applied weight on the load cells is then printed or visually readout by the data presentation device.

Details of Elements

Load cell consists essentially of a calibrated steel loading column, four strain gages bonded to the sides of the column and a hermetically sealed metal container. The four strain gages, each consisting of a fine resistance wire laid back and forth on a thin strip of impregnated paper, are connected electrically in the form of a wheatstone bridge. Two diametrically opposite corners of the bridge are connected in series with the input terminals of the load cell. The other two diametrically opposite corners serve as the output terminals of the load cell.

During operation, a constant ac voltage is impressed across the input terminals of the cell. Magnitude of the resultant voltage which appears across the output terminals of the cell depends entirely on the degree of electrical unbalance existing in the strain gage bridge circuit—the greater the unbalance, the greater the output voltage. For no-load conditions, the output voltage of the cell is equal to zero. This is due to the fact that when the strain gages are not under stress, the resistance of each is of such a value that the bridge is in electrical balance.

When a load is placed on the steel loading column, both the column and attached strain gages are slightly deformed. The deformation occurring in the strain gages changes the respective resistance value of each, which in turn, unbalances the bridge. Since the bridge is no longer in electrical balance, a small resultant voltage appears at the output terminals of the cell. Due to careful calibration of the cell, this small output voltage is proportional to the amount of the load the cell is sup-

porting. Proper instrumentation is then utilized to measure the voltage and determine the amount of load it represents.

The servosystem measures the load cell output voltage by comparing it with a reference ac voltage. Major components of the servosystem, *Fig.* 1, are, a balance bridge, an amplifier, a two-directional servomotor and a zero-adjust bridge. Initially, with no load on the load cell and therefore, zero output voltage, the system is at zero balance. However, if a load is placed on the load cell, the output voltage increases a corresponding amount and a finite portion of this voltage appears across the amplifier input terminals. The amplifier increases the impressed voltage considerably and then directs it to the servo balance motor. The servomotor as a result starts to operate and drive through a mechanical gear system both the rotary precision potentiometer in the balance bridge and the movable element of the data presentation device—pointer of a dial, digit wheels in a printer, etc.

Due to the adjustment of the precision potentiometer, a portion of the reference voltage appears across the balance bridge between points *X* and *Y*. This resultant voltage across the bridge is in opposition to the load cell voltage and progressively increases in value as long as the servomotor continues to drive the potentiometer slider away from its original position, point *a*. The servomotor continues to run until the balance bridge opposing voltage is equal in magnitude to the load cell voltage. The motor then stops because the two voltages have cancelled one another out, leaving zero voltage impressed across the amplifier input terminals, or zero power to further drive the motor.

This constitutes a balance point for the system and it will remain as such until the load cell voltage is changed. Since the servomotor, the precision potentiometer and the data presentation device all work synchronously with one another, the weight reading represented by the load cell voltage has also been positioned on the data presentation device and may be immediately printed or visually read out. When the weight is removed from the

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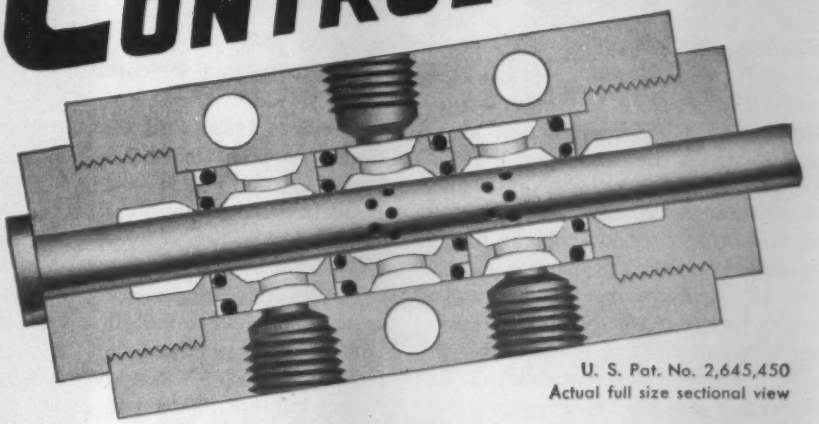

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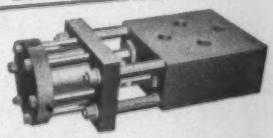

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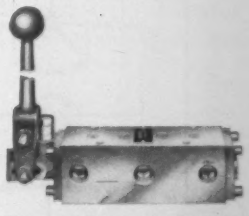

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load cell, the system reverses the above procedure and returns to a normal zero balance position.

The zero-adjust bridge is used to bring the recorder to a proper zero balance. This device consists of a potentiometer which serves as a separate voltage source and a voltage divider for the voltage source. The adjustment of this potentiometer permits one to obtain a proper zero balance of the recorder by producing a voltage which is equal and opposite to an undesired voltage in the measuring circuit. Also, any slight zero shifts which might occur due to temperature variations or other causes can be readily compensated by adjusting this control. In many cases this control is used to cancel out the voltage due to a weighbridge or other form of load receiving element on the load cells.

If tare weight compensation is desired in a scale, a device similar to the zero-adjust control, consisting of another separate voltage source and potentiometer, is incorporated into the servosystem. However, in this case the potentiometer is varied by means of a hand dial calibrated in weight units. The dial is set to the indicated tare weight for each load. For example, if a box having a known tare weight of 500 lb and containing several castings is placed on the scale and only the weight of the castings is desired, the tare weight compensating dial is set to 500. At this setting the tare weight potentiometer produces an opposing voltage which cancels out the portion of load cell output voltage due to the weight of the box. The servosystem therefore detects only the portion of the load cell output voltage due to the castings, and as a result, the weight of the castings alone is readout by the data presentation device.

Data Processing Potential

Since the angular displacement of the servomotor shaft is proportional to the applied weight, it may be utilized to mechanically position data presentation elements such as the pen of a strip chart, the pointer of a visual dial, geneva pinion interconnected visual digit wheels or the printing mechanism of a recorder. A step cam and sensing finger system is used in some full figure printing recorders to convert the angular displacement of the servomotor into discrete digits. Step cams, geared to the servomotor, are rotated to a corresponding position whenever the servosystem seeks a null balance point for a weight. Then, once the servomotor has brought the step cams to a standstill balance position, the sensing fingers move forward from their waiting positions and engage the cams. The length of travel of each finger depends on the depth of the particular step aligned in front of it, while the depth in turn corresponds to a certain dig . As each sensing finger moves fo ard, its attached rack meshes wi the pinion of its associated typ heel and rotates the wheel to a pr ting position corresponding to th digit being detected on the step cam. Once all of the typewheels have been positioned in this manne the print hammer snaps down an records the value of the weig t on a card or tape held immedi tely above the typewheels. The sensing fingers then move back to their waiting positions until the next weight is to be printed.

Applications

Load detection may be accomplished in electronic weighing systems, *Fig.* 2, by placing load cells under a conventional weighbridge, by utilizing a crane scale load cell with attached hook or by incorporating load cells into various types of equipment in a great number of diverse ways. Cables convey the electrical weight information from the load cell to the instrument of the electronic scale. For simple scale applications, the instrument contains the servosystem and one or more data presentation devices, such as a printer or a printer combined with a visual dial. When batching, regulation, intermittent feeding, and other automatic processes are involved, additional instrumentation is included in the weighing system.

The load cell has as one of its many useful characteristics, the quality of being able to convert a weight force into a proportional voltage in a fraction of a second. This fast response time will undoubtedly pave the way to various high speed motion-weight installations. Envisioned, and perhaps already under test, are electronic scales capable of detecting weights of vehicles moving at speeds of 60 mph and greater.

As another illustration, consider the crane scale. In its present form it has proved to be a very versatile device and those companies using it are very enthusiastic about its ability to substantially reduce the number of operations required in the handling and weighing of heavy materials. However, if the spring reel and intercon-

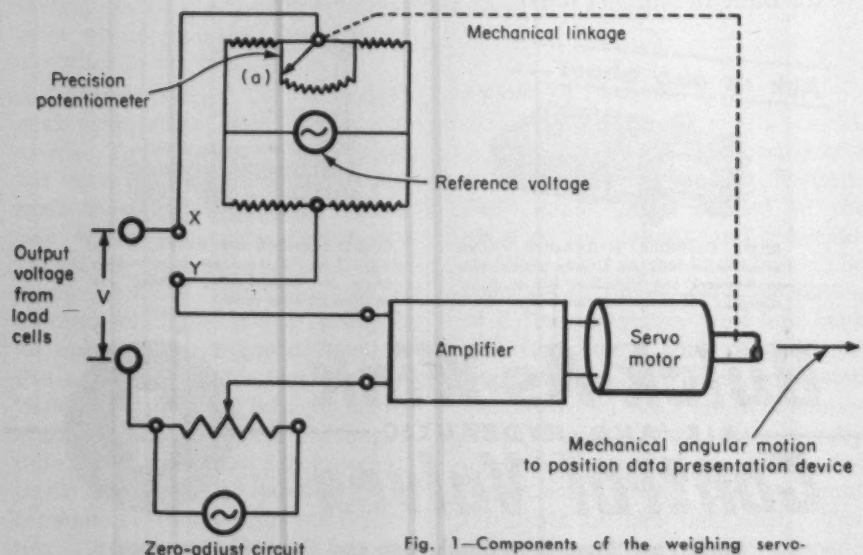

Fig. 1—Components of the weighing servosystem, a balance bridge, an amplifier, two-directional servomotor and a zero-adjust bridge

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Hobbing
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Brake Forming
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Wire Forming
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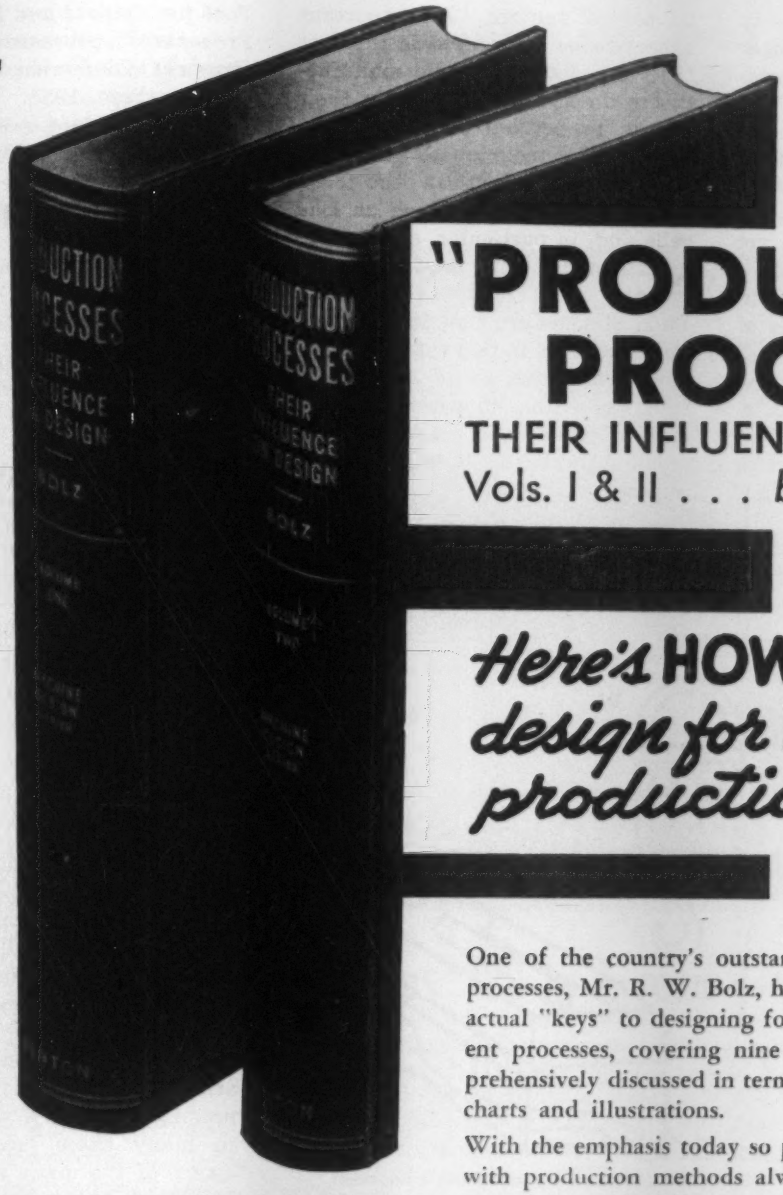

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necting cable of this scale were to be replaced by a radio transmitter and receiver arrangement to transmit weight data from the load cell to the recorder, it is seen that the versatility of the scale would be greatly enhanced.

The fact that the load cell is relatively very small in size has yet to be fully exploited. The possibility of incorporating load cells directly into the lifting apparatus of a fork lift truck and installing a recorder on the dashboard is perhaps immediately possible. Likewise load cells and a recorder could be installed in a dump truck, milk truck, oil truck and many other types of vehicles.

Whether these scales will be realized in the near future will depend on several factors. An important aspect to be considered is the fact that the electronic scale manufacturers do not stand alone in their efforts to develop better components and techniques. Actually equipment inherent in the electronic weighing field such as load cells and, in particular, servomechanisms is also being used extensively in a great many other fields. Thus, chances are that forthcoming improvements in this type of equipment will occur at an accelerated rate and these improvements will lead to rapid advances in the electronic weighing field as well as the others.

From a paper entitled, "Electronic Weight Determination As a Tool for Control and Measurement Procedures" presented at the Instrument Conference of ASME in Chicago, Sept. 1953.

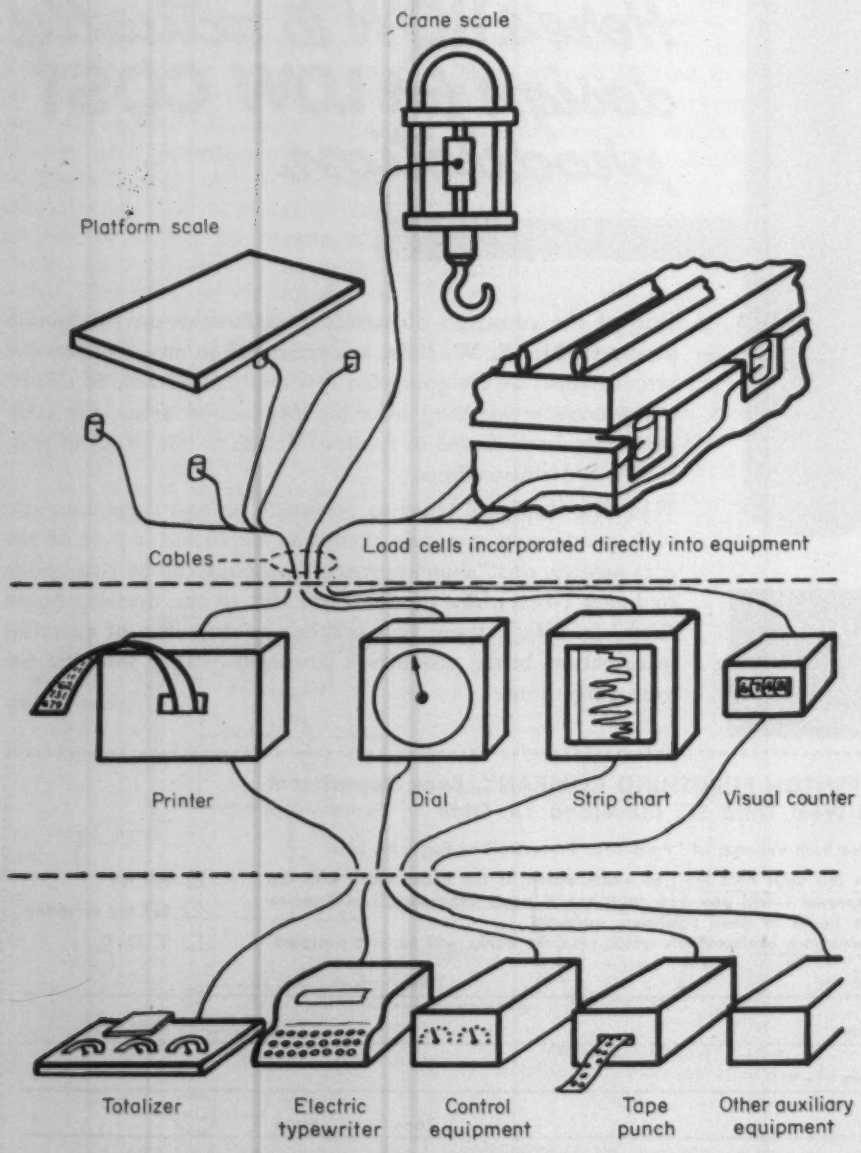

Fig. 2—Basic scale systems showing combinations of equipment used to provide the desired weighing method with a desired data processing vehicle

STANDARDIZE NOW

By R. E. GAY
American Standards Association
New York, N. Y.

INDUSTRY must begin to redesign its standards with the same care that it uses to plan its new factories, to design its new machines, or to schedule its production flow with marketing techniques. Only by doing so can industry make effective use of new technologies, including that of automation.

The time to start is now; standards cannot be developed at short notice for they take time. And standards that are preplanned may take even longer to develop than those standards for which the urgent need has become obvious through chaos and confusion. In whatever field standards are needed for the purpose of planning for the future, the standards themselves must be available ahead of time and, therefore, must be planned ahead of time.

Until recently, too many business executives have considered standardization primarily as an engineering problem. Top management, in many cases, seems not fully aware of the many millions of dollars that are wasted for lack of standardization or for neglecting to comply with existing standards, even now, under our early automation industrialism. Such waste is bound to be magnified a hundredfold in the far more intricate production processes of automation. Automation will compel the industrialist to enlarge his vision and take over new responsibilities.

Automation could make it necessary to redesign completely a manufacturing process, the product, and the machinery. Often far more is involved than simply fitting automatic controls to our present operations. The end use of the product coupled with the new production process of automation will have to decide the final form of the product. We should not, as we did during the industrial revolu-

tion, try to fit a gasoline engine to a horse carriage. The first automobile even had a holder for a buggy whip.

The nature of a particular market may limit the degree to which automation can be successfully employed. New markets may have to be planned and created in order to convert an industry to automation. The versatility, pioneering spirit, and engineering knowledge of a Henry Ford or a Leland Olds will be required to make such a conversion possible. The top executive will have to be an all-round man.

An automation engineer will have to be trained in many branches of engineering. He must understand instruments, welding, stamping, heat treating and all the industrial operations and methods. Then he should know in detail the processes of his particular industry. Finally he should have a sound knowledge of the economics of automation. And naturally, we expect him to understand the principle and necessity of planned standardization in advance of need.

Standardization of such giant equipment as transformers indicates that standards do not have to be confined to engineering details and component parts. Standardization of large equipment will probably be of great importance in the field of automation. The first cost of automatic control equipment will be so much greater than that of any conventional equipment that no single industry can afford duplication and confusion as existed under our empirical method of developing standards.

The only way to avoid such costly duplication and confusion is by planned standardization in advance of need. We believe that standardization is a great frontier of American industry where major increases in efficiency and substantial cuts in costs can be made. Planned standardization should be and will be one of the most important management functions.

From an address entitled, "The Role of Standards Men in the Second Industrial Revolution" presented at the Third General Conference of the Joint Electron Tube Engineering Council in Atlantic City, N. J., Sept. 1954.

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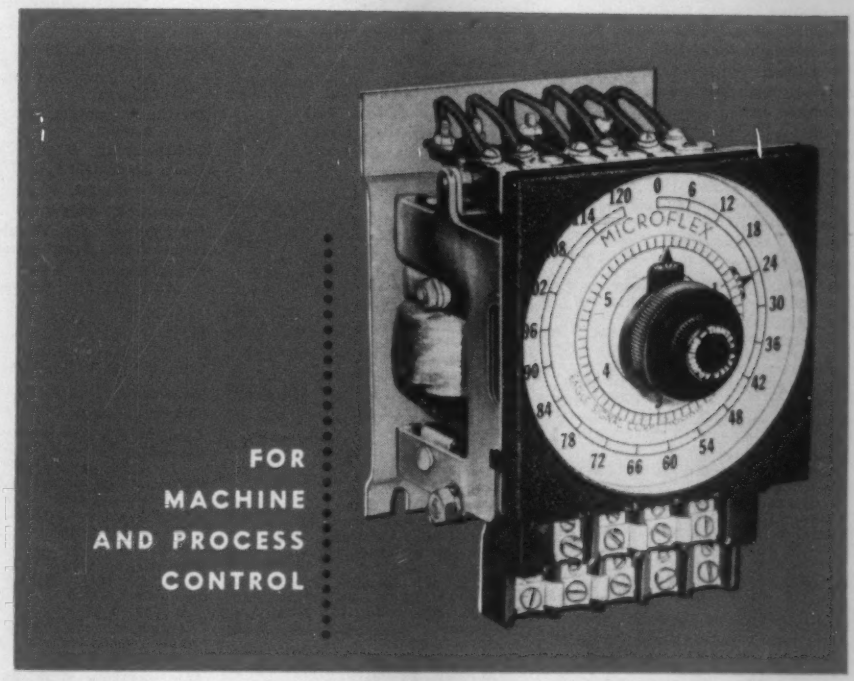

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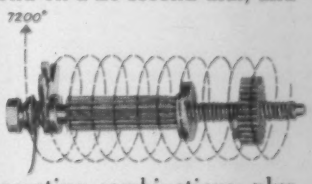

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